CHAPTER 5

Classifying Matter

Getting Ready...

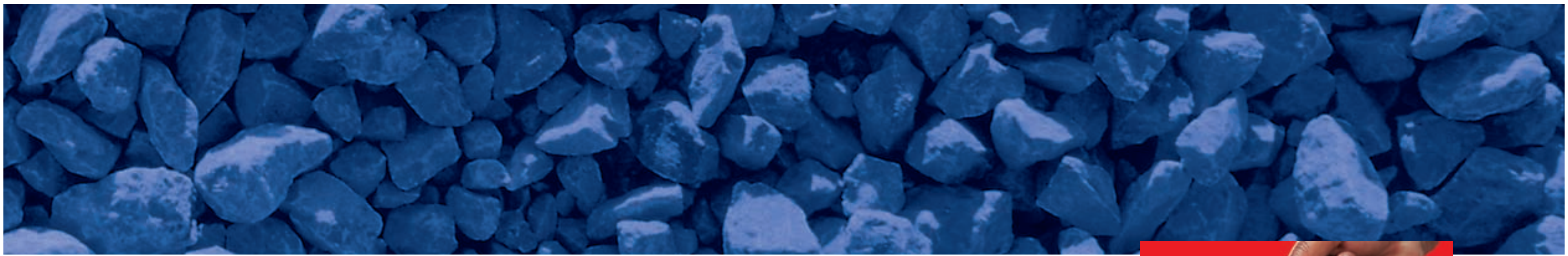
- What is a mixture?
- Is any matter not a mixture?
- How can you get useful materials from mixtures?
- What do scientists think the smallest particles of matter are like?

A dipnet is a kind of filter that separates fish from water. What other kinds of filters can you think of?

What do these two photographs have in common? The person in the large photograph is fishing with a dipnet. A dipnet is a traditional Aboriginal tool for catching fish. The dipnet catches large fish but allows smaller fish and gravel to go through the holes. Water flows through the holes, too.

The scientist in the photograph on the next page is separating different kinds of matter with a gas chromatograph (GC). Separating different types of matter is the first step in identifying matter. Forensic scientists use the GC to analyze evidence such as charred wood. The outcome of an arson case may depend on knowing whether or not a sample of charred wood has gasoline on it.

Both the dipnet and the GC use properties to separate mixtures into their parts. The dipnet uses the properties of size and state of matter. The GC uses other properties. In this chapter, you will learn about different methods for separating materials into their parts. As well, you will find out how you can use the properties of materials to classify them.



What You Will Learn

In this chapter, you will learn

- how to identify the mixtures all around you
- how to distinguish between different kinds of mixtures
- what theory will help you visualize particles of matter

Why It Is Important

- You eat, wear, breathe, and use mixtures every day.
- Many mixtures, such as gold ore, contain important substances that people can extract using their knowledge of physical changes.

Skills You Will Use

In this chapter, you will

- classify materials as mixtures or pure substances
- communicate observations about mixtures you use every day
- investigate different ways to separate mixtures

This scientist is using a GC to help identify the types of matter in a sample. Why might this be important evidence in a court case?

Starting Point ACTIVITY 5-A

Mixture or Pure Substance?

Do you read the labels on packages? Some labels claim that the product in the package is "pure." Are these claims accurate? Does "pure" mean the same to a consumer as it does to a scientist? In this activity, you will classify some common materials as either mixtures or pure substances.

What to Do

Group Work

1. In groups, decide how you would define the terms "mixture" and "pure substance." **Record** your definitions.
2. Prepare a table of observations like the one below. Give your table a title.

Product	Mixture or pure substance?	Reasons

3. Brainstorm a list of common products that you might find in a bathroom or kitchen.
4. Choose ten products that you want to **classify** as a mixture or pure substance. **Record** the names of the products in your table.
5. As a group, decide whether each product is a pure substance or a mixture. Use the definitions you created in step 1. **Record** your decisions, and the reasons for each decision, in your table.

What Did You Find Out?

1. In a large table, compile a class list of the products examined. How many products were classified as mixtures? How many products were classified as pure substances?
2. Which products were difficult to classify? Which products were easy to classify? Suggest reasons.

Section 5.1 Pure Substances and Mixtures

Figure 5.1 Is this fabric a mixture? How do you know?

Figure 5.2 Suppose that you examined several different samples of concrete. Do you think all the samples would have the same density? Would they all have the same hardness?

Most solids, liquids, or gases that you see and use every day are mixtures. A **mixture** contains two or more different types of matter. How can you tell that a sample of matter is a mixture? Many products in your home, such as hand lotion and shampoo, have long lists of ingredients. An ingredient list tells you all the ingredients that are contained in a product. If an ingredient list has more than one ingredient, the product is clearly a mixture! For example, examine the clothing tag in Figure 5.1. What is the fabric made of?

Not every object that you encounter has an ingredient list. Is a sandy beach a mixture? Is an ocean a mixture? How can you tell?

Heterogeneous Mixtures

Whenever you see a sample of matter that has more than one set of properties, you know for sure that it is a mixture. For example, a sandy beach may contain white grains of sand, multicoloured seashells, and brownish-green seaweed.

The concrete wall shown in Figure 5.2 is also a mixture. You can see that it contains a variety of stones with different shapes, sizes, and colours. If you have watched someone make concrete, you may know that concrete also contains sand, cement powder, and water.

Concrete is a good example of a heterogeneous mixture. A beach is another example. A **heterogeneous** [het-uhr-oh-JEEN-ee-uhs] mixture is made up of different parts that you can detect quite easily. Often, you can see the different parts just by looking at the mixture. Sometimes you need a microscope to see the different parts.

Pure Substances

Is there anything that is *not* a mixture? What about a bar of pure gold? Pure gold contains nothing but gold. Every sample of pure gold has the same properties as every other sample of pure gold. For example, a nugget of pure gold from Barkerville, British Columbia, has the same melting point, hardness, and density as the nugget of pure gold from Yanacocha, Peru.

Pure gold is an example of a pure substance. A **pure substance** is the same throughout. Every sample of a pure substance always has the same properties. Other examples of pure substances are helium, pure water, and white sugar. Pure substances are homogeneous materials. **Homogeneous** [hoh-moh-JEEN-ee-uhs] means that every part of the material is the same as every other part.

READING Check

What is a pure substance? Give three examples of pure substances.

Homogeneous or Heterogeneous?

How do you decide whether a sample of matter is a pure substance or a mixture? One way is to observe whether the sample is homogeneous or heterogeneous. Heterogeneous materials are always mixtures. Sometimes, though, you cannot tell whether a sample of matter is homogeneous or heterogeneous just by looking at it. For example, is milk homogeneous or heterogeneous? Milk appears homogeneous, but under a microscope, you can see that it contains "blobs." These "blobs" are called globules. Figures 5.3 shows a sample of milk under a microscope. One single drop of milk contains about 100 million fat globules. The globules are so tiny that milk seems to be homogeneous even though it is not. Do you think it is possible to have a homogeneous mixture? Find out in the next activity.

DidYouKnow?

Many years ago, it was easy to see that milk is a heterogeneous mixture. Instead of staying mixed with the milk, the fat globules floated to the top. There, they clustered together, forming a layer of cream. Today, milk is *homogenized*. Homogenized milk is specially prepared so that the fat globules remain mixed with the rest of the liquid.

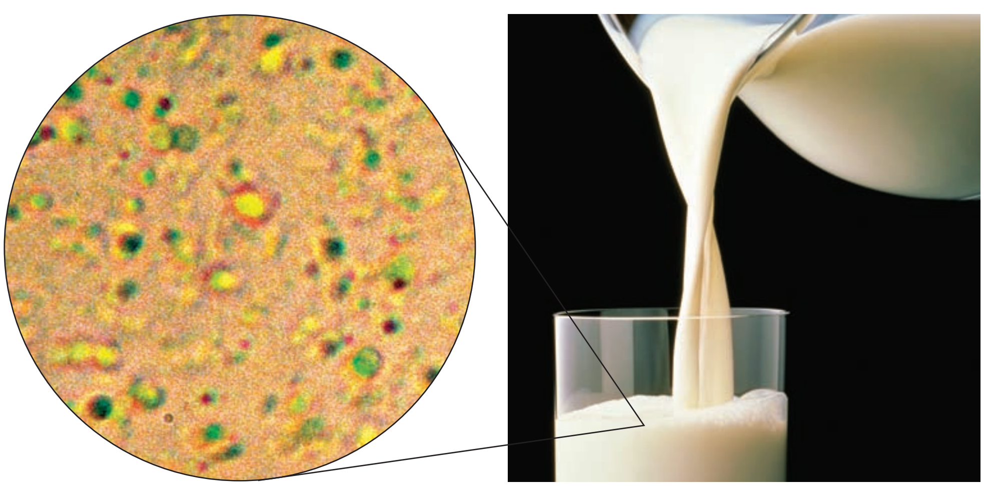


Figure 5.3 The round photograph shows how milk looks under a microscope. The milk is magnified 400 times. How can you tell, from the microscopic image, that milk is heterogeneous?

At Home **ACTIVITY 5-B**

Making Sugar "Disappear"

Can you make a mixture in which you cannot detect the different parts? The two substances you will mix are sugar and water.

Safety Precautions

Do not taste the samples if you are doing this activity in class. You may taste the samples if you are doing this activity at home.

What You Need

drinking glass
tap water
white sugar
teaspoon

What to Do

1. Make a table of observations like the one below. Give your table a title.

Observable properties	Sugar	Water	Sugar-water mixture
colour			
state			
taste			
transparency			

2. **Observe** the four properties of sugar and water that are listed in the table. **Record** your observations.
3. Fill a glass with cold water. Let it sit for a few seconds, until the water is still. Gently pour one level teaspoon of sugar into the water. **Observe** the appearance of the water and the sugar. Place the glass where it will not be moved for 24 h.
4. **Observe** the contents of the glass the next day. **Record** the properties of the mixture in your table.

What Did You Find Out?

1. Can you detect either of the two substances in your mixture as different parts?
2. Is the sugar present in the mixture or not? How do you know?
3. How do the properties of the sugar-water mixture compare with the properties of the sugar and the properties of the water? Choose one of the following statements. Record it, and give reasons for your choice.
   - The mixture has all the properties of water and *only* these properties.
   - The mixture has all the properties of sugar and *only* these properties.
   - The mixture has a blend of sugar's properties and water's properties.

READING Check

What kind of mixture is milk? What kind of mixture is sugar and water? Explain the difference.

Homogeneous Mixtures

When you mix sugar with water, the sugar crystals disappear from view. *You cannot see them, even with a microscope.* A sugar-water mixture is an example of a homogeneous mixture. Homogeneous mixtures contain two or more pure substances. The substances are mixed so that their properties are blended and every part of the mixture is the same.

What other homogeneous mixtures can you think of? In the next investigation, you will practise classifying mixtures as either homogeneous or heterogeneous.

CONDUCT AN

INVESTIGATION 5-C

SKILLCHECK

- Hypothesizing
- Observing
- Classifying
- Communicating

Inspector's Corner

How can you determine whether a mixture is homogeneous or heterogeneous? Your challenge in this investigation is to inspect several products in your home and classify them.

Question

How can you classify common household products as homogeneous or heterogeneous mixtures?

Hypothesis

Write a hypothesis about the properties of homogeneous and heterogeneous mixtures that will help you classify them. Your hypothesis should take the form "If… then… because…."

Skill POWER

For tips on writing a hypothesis, turn to SkillPower 6.

Safety Precautions

Materials

variety of common household mixtures, such as orange juice, apple juice, jam, cereal, salsa, toothpaste, skin cream, and soap

Procedure

1. Prepare a table of observations like the one below, to record your observations. Give your table a title.

Product	Observations	Heterogeneous or homogeneous?	Reasons for classification

2. **Observe** each product carefully. **Record** your observations in your table.

3. **Classify** each product as a heterogeneous or homogeneous mixture. **Record** your classification in your table.

4. Under "Reasons for classification," identify and describe the properties of each product that helped you classify it.

5. Put away all the products. Clean up any spills, as instructed by your teacher.

Analyze

1. Propose a test that you could use to classify a product as homogeneous or heterogeneous.

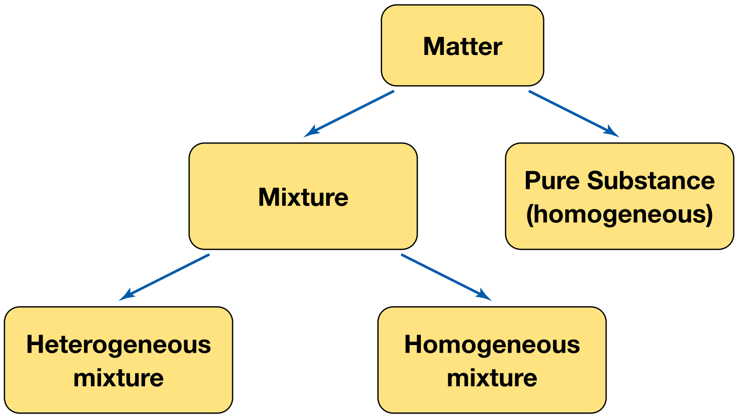
Conclude and Apply

2. Re-examine your hypothesis. How well did your results support your hypothesis? Modify your hypothesis to reflect your results.

3. Compare your conclusions with the conclusions of other students. Which products were easier to classify? Which products were more difficult to classify? Why?

Section 5.1 Summary

In this section, you learned that samples of matter can be either pure substances or mixtures. You also learned how to classify matter as homogeneous or heterogeneous.



- Homogeneous materials have the same properties throughout.
- Heterogeneous materials have different parts with different properties.
- Pure substances contain only one type of matter. They are homogeneous.
- Mixtures contain two or more types of matter. Mixtures can be heterogeneous or homogeneous.

The chart above summarizes what you have learned so far about matter. You will add to this chart in the sections that follow. In section 5.2, you will learn more about homogeneous and heterogeneous mixtures.

Key Terms

mixture
heterogeneous
pure substance
homogeneous

Small bits of solids hang in polluted air. These bits cause the air to appear cloudy from a distance.

Check Your Understanding

1. (a) What are two examples of mixtures?
   (b) What are two examples of pure substances?

2. Classify each mixture as homogeneous or heterogeneous. Explain your classification.
   (a) milk
   (b) pulpy orange juice
   (c) apple juice
   (d) window cleaner
   (e) pizza
   (f) sports drink crystals

3. Heterogeneous materials are always mixtures. Are homogeneous materials always pure substances? Explain your answer.

4. **Apply** When you first open a bottle of soda, the liquid is filled with tiny bubbles.
   (a) Is the bubbly soda homogeneous or heterogeneous? Explain your answer.
   (b) If you let the soda sit for a day, what happens? Is the mixture heterogeneous or homogeneous now?

5. **Thinking Critically** The photograph on the left shows polluted air—smog. Smog is air that contains solid and gaseous pollutants.
   (a) Is smog a heterogeneous or homogeneous mixture?
   (b) Why do you think breathing smog can be harmful?

Section 5.2 Classifying Mixtures

In Chapter 4, you classified matter as a solid, a liquid, or a gas. In section 5.1 of this chapter, you classified matter as a pure substance or a mixture. What are some different kinds of mixtures?

Mechanical Mixtures

Mixtures that are clearly heterogeneous are called **mechanical mixtures**. You can see the different types of matter in mechanical mixtures. Many foods, such as sandwiches, salads, salsa, and stir-fried vegetables, are mechanical mixtures. Another example of a mechanical mixture is pizza, shown in Figure 5.4.

Figure 5.4 You can see the crust, sauce, cheese, and toppings on a pizza. A pizza is a mechanical mixture.

Suspensions

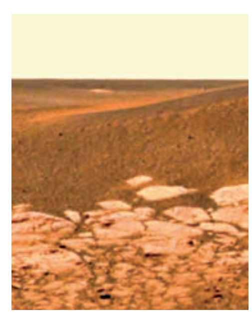
A heterogeneous mixture in which the particles settle slowly after mixing is called a **suspension**. An example of a suspension is oil and vinegar salad dressing. Before shaking the salad dressing, you can see the oil and vinegar parts of the mixture. Often the dressing contains herbs and spices, as well. When you shake the mixture, the herbs, spices, and vinegar become suspended in the oil. They soon separate, however, when you put down the bottle. How can you make the bits of matter in a suspension remain suspended longer? You will find out in the next activity.

Pause& Reflect

In your science notebook, list three foods, drinks, or other household mixtures (not already mentioned in this textbook) that are mechanical mixtures. Explain why they are mechanical mixtures.

DidYouKnow?

The sky on Mars is a pinkish-yellow colour. What causes this colour? The Mars atmosphere is actually a suspension of very tiny pieces of red dust.



Find Out **ACTIVITY 5-D**

Keep It Together!

Oil and vinegar salad dressing is an example of a suspension. Manufacturers of salad dressings often add substances that slow down the separation of the parts of the mixture. These substances are called *emulsifying agents.* In this activity, you will observe the effect of one emulsifying agent.

What happens when you add dishwashing liquid to a suspension?

What You Need

cooking oil
vinegar
jar with tight-fitting lid
dishwashing liquid (not dishwasher detergent)
watch or clock with second hand or counter

What to Do

1. Place equal amounts of cooking oil and vinegar in the jar. Put on the lid to seal the jar tightly.
2. Shake the jar thoroughly, and then put it down. **Measure** how long the two liquids take to separate. **Record** the time in seconds.
3. Add two drops of dishwashing liquid to the mixture in the jar. Again, shake the jar thoroughly. How long do the two liquids take to separate now? **Record** the time.
4. Leave the mixture undisturbed overnight. **Observe** it in the morning. **Record** your observations.

What Did You Discover?

1. Describe the effect of the dishwashing liquid on the mixture.
2. Did adding the dishwashing liquid cause a permanent suspension to form?

READING Check

What is the difference between a suspension and an emulsion? Give one example of each kind of mixture.

Emulsions

In the last activity, you added dishwashing liquid to a suspension of oil and vinegar. You probably observed that the dishwashing liquid enabled the suspended particles to stay suspended longer. As you learned, the dishwashing liquid acted as an *emulsifying agent.* An emulsifying agent allows the parts of a suspension to remain distributed through the mixture for a longer period of time. A suspension that has been treated with an emulsifying agent is called an **emulsion**. Mayonnaise is one example of an emulsion. Paint is another example.

An emulsion may appear to be a homogeneous mixture, but it is not. You can see the different parts of an emulsion under a microscope. Both emulsions and suspensions are heterogeneous mixtures.

Solutions

Homogeneous mixtures are called **solutions**. You made a solution in At Home Activity 5–B. Apple juice, vinegar, and tap water are all solutions. So is the window cleaner shown in Figure 5.5. A solution is made when two or more substances combine to form a mixture that looks the same throughout, even under a microscope.

Solutions are everywhere. Seawater is a solution of salts and water. Air is a solution of nitrogen, oxygen, carbon dioxide, and other gases. There are even solutions of solids, such as the objects shown in Figure 5.6. Solutions that are made from two or more metals are known as **alloys**.

Why make an alloy? You can change the properties of a metal by adding small amounts of other substances. For instance, jewellery made out of pure gold would become scratched very easily, because gold is so soft. Adding silver or copper to gold makes a gold alloy that is harder than pure gold. As an added benefit, silver and copper are cheaper than gold!

Figure 5.5 Window cleaner is a solution of ammonia and other substances in water.

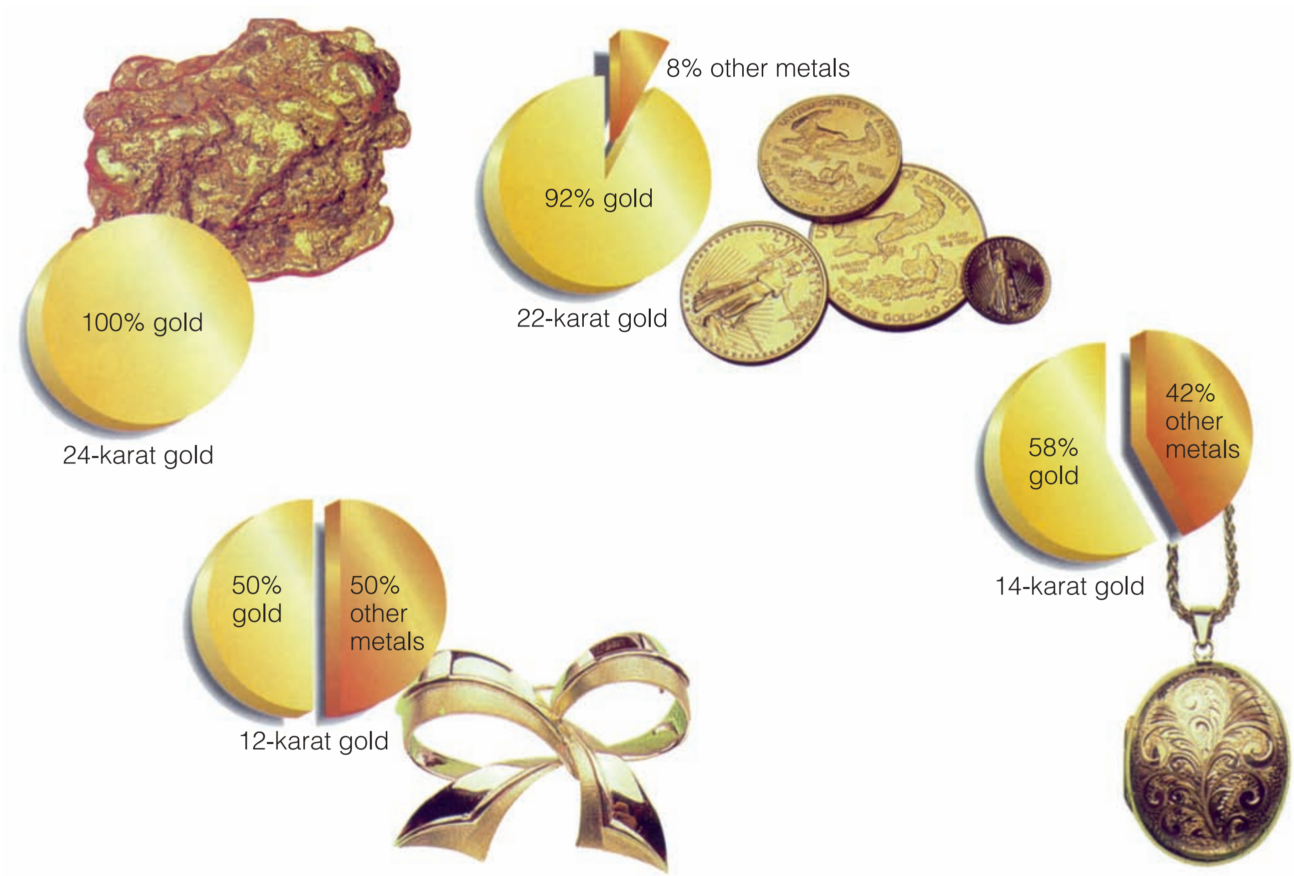


Figure 5.6 The circle graphs show the percentages of gold and other metals found in the different "gold" objects. Which of these objects are pure substances? Which are mixtures?

READING Check

What is another way of saying "Water and salt form a solution when mixed"? Use the word "dissolve."

Parts of a Solution

When you mix two substances and they form a solution, you say that one substance **dissolves** in the other substance. As you can see in Figure 5.7,

- the **solute** is the substance that dissolves
- the **solvent** is the substance in which the solute dissolves

When you mix salt and water, for example, the salt is the solute, and the water is the solvent. The salt dissolves in the water.

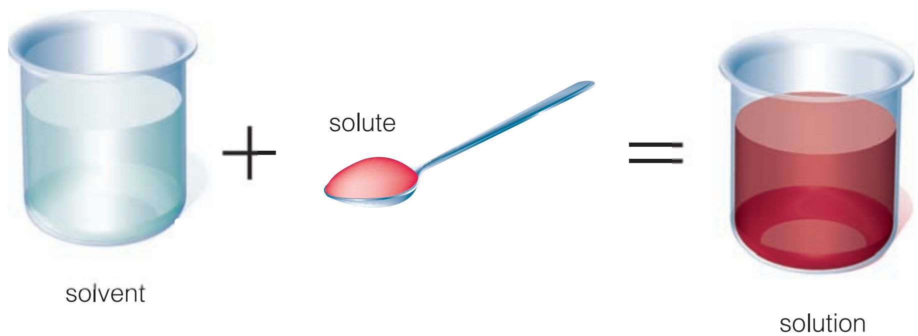


Figure 5.7 The solute dissolves in the solvent to form a solution.

Table 5.1 Examples of Solutions

Solution	Solute and solvent	State of solute	State of solvent
air	oxygen and other gases in nitrogen	gas	gas
soda water	carbon dioxide in water	gas	liquid
vinegar	acetic acid in water	liquid	liquid
filtered seawater	sodium chloride (salt) and various minerals in water	solid	liquid
brass	zinc in copper	solid	solid

Table 5.1 provides some examples of solutions, with their solutes and solvents. There is usually less solute than solvent in a solution. If you read the labels on liquid products around your home, you will notice that water is the solvent for many different solutes.

Solution or Mechanical Mixture?

How can you tell if a mixture is a solution or a mechanical mixture? Often you can tell by just looking. What if you cannot?

- Use a microscope. If the mixture is a solution, you will be able to see only one type of matter, even under a microscope.
- If the mixture is a liquid, pour it through a filter. If anything is caught in the filter, then the mixture is definitely mechanical.
- Shine a light through the mixture. Solutions contain no undissolved particles and do not scatter light. Therefore, you will *not* see a beam running through a solution. A heterogeneous mixture, however, *does* contain undissolved particles that can scatter light. Which mixture in Figure 5.8 is a solution?

Figure 5.8 The tiny, undissolved particles in the mixture on the right reflect and scatter the light. You see the light as a beam running through the mixture.

CONDUCT AN

INVESTIGATION 5-E

SKILLCHECK

- Observing
- Classifying
- Predicting
- Communicating

What Kind of Mixture?

One way to tell whether a mixture is a solution or a heterogeneous mixture is to pour the mixture through a filter. In this investigation, you will practise using a filter.

Question

How can a filter help you decide whether a mixture is a solution or a heterogeneous mixture?

Safety Precautions

Apparatus

funnel

4 beakers or jars

Materials

4 mixtures

4 pieces of filter paper

cardboard with hole for funnel

Procedure

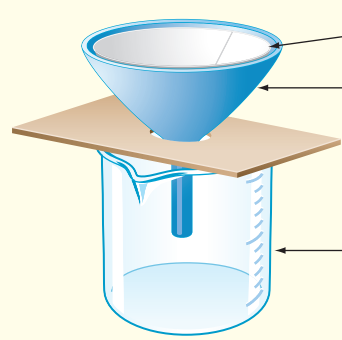
1. Copy the following table into your science notebook. Give your table a title.

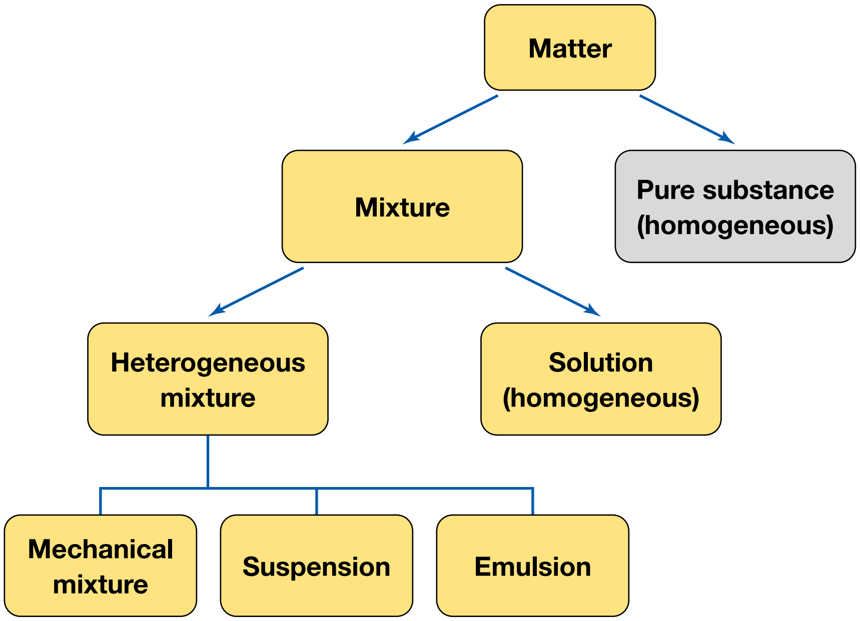
Mixture	Prediction: heterogeneous mixture or solution?	Observations before filtering	Observations after filtering	
			In filter	In beaker

2. Your teacher will provide you with four household mixtures.
3. **Observe** each mixture. **Predict** whether it is a solution or a heterogeneous mixture. Write your prediction in your table.
4. Pour each mixture through a filter.
5. For each mixture, **observe** the substance that went through the filter. Was anything left in the filter? **Record** your observations in your table.
6. Wipe up any spills, and wash your hands thoroughly.

Analyze and Conclude

1. Which of your observations matched your predictions? Did any observations surprise you? Explain your answer.
2. If you observe matter on the filter, can you state that the mixture is definitely a heterogeneous mixture? Explain your answer.
3. If you do not observe any matter on the filter, can you state that the mixture is definitely a solution? Explain your answer. If you answered "no," what are some ways you can tell that a mixture is definitely a solution?





Section 5.2 Summary

In this section, you learned how to classify mixtures as heterogeneous mixtures or solutions. You learned that mechanical mixtures may be ordinary mechanical mixtures, suspensions, or emulsions. You can now add to your classification of matter chart, as shown on the left.

Key Terms

mechanical mixtures
suspension
emulsion
solutions
alloys
dissolves
solute
solvent

Check Your Understanding

1. How would you classify each mixture: as a solution, a mechanical mixture, a suspension, or an emulsion?
   (a) bran cereal with raisins
   (b) paint with an ingredient that prevents separation
   (c) oil and vinegar salad dressing
   (d) 18 karat gold ring
   (e) filtered air

2. (a) What kind of mixture is an alloy?
   (b) What are two different kinds of alloys?
   (c) Why are alloys sometimes more useful than pure metals?

3. How are a solution, a suspension, and an emulsion different? How are they the same? Give one example of each. (Do not choose examples from question 1.)

4. **Apply** Suppose that your teacher gives you a liquid mixture. You cannot see any small pieces of different matter in the mixture. When you filter the mixture, nothing is left on the filter paper.
   (a) Is the mixture a solution or a heterogeneous mixture? Explain your inference.
   (b) How could you be more certain about your classification? What tests would you carry out? What equipment would you need?

Section 5.3 Pure Substances

The crown looked like pure gold, but was it?

In Chapter 4, you learned that Archimedes discovered the method of displacement for finding volume. He used the method of displacement to solve a problem for Hiero II, the ruler of Syracuse.

Hiero II suspected that the royal goldsmith had not used pure gold to make his crown. The king asked Archimedes, shown on the right, to determine whether or not the crown was made entirely of gold. Archimedes knew that he could determine whether the density of the crown matched the density of pure gold. He measured the mass of the crown on a balance. Then he determined its volume by displacement. Archimedes found that the crown was less dense than pure gold. The goldsmith had tried to cheat the king by mixing pure gold with silver, which is less dense *and* less valuable!

Identifying Pure Substances

Archimedes used the property of density to determine whether the crown was made of a pure substance or a mixture. You can also use boiling point or melting point to determine whether a material is a pure substance or a mixture. Pure substances boil and freeze at constant, known temperatures. Mixtures boil and freeze at different temperatures than the pure substances that make them up. This property of mixtures is used to keep roads clear of ice in the winter, as shown in Figure 5.9.

READING Check

What properties can help you identify a pure substance?

Figure 5.9 Pure water freezes at 0°C. By adding salt, you create a mixture that stays liquid at much lower temperatures.

Pure Substances and the Particle Model of Matter

Why do pure substances always have the same properties? In Chapter 4, you learned about the first four points in the particle model of matter. Scientists use the fifth point in this model to explain how pure substances are different from mixtures.

- Each pure substance has its own kind of particle, which is different from the kinds of particles that make up all other pure substances.

For example, pure gold contains only gold particles. Pure water contains only water particles. Because a pure substance is always made up of exactly the same kind of particles, it always has the same properties.

The particles that make up matter are so tiny that you cannot see them, even with a microscope. How many sugar particles do you think are in a sugar cube? See Figure 5.10 to find out.

Did You Know?

Just how tiny are the particles that make up matter? A 250 mL glass of water contains about 8 billion billion billion water particles. That's 8 000 000 000 000 000 000 000 000 000 water particles in a glass of water. No wonder you cannot see them!

Figure 5.10 A single grain of sugar contains about 1 800 000 000 000 000 000 sugar particles. A sugar cube contains about 2 700 000 000 000 000 000 000 sugar particles.

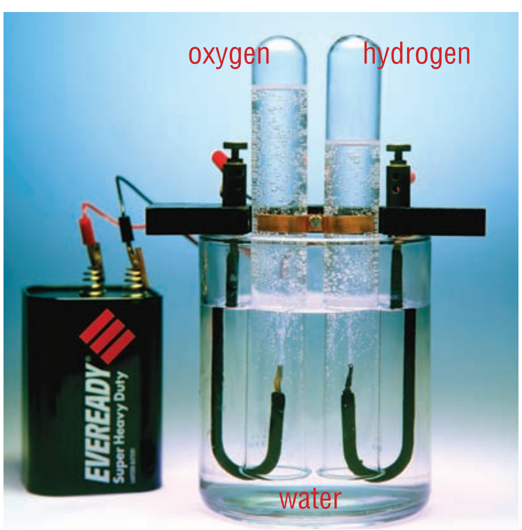


Figure 5.11 When electricity is run through water, hydrogen and oxygen are produced.

Classifying Pure Substances

In section 5.2, you learned that mixtures can be classified as mechanical mixtures, suspensions, emulsions, and solutions. Pure substances can also be classified into different groups. These groups are based on whether the pure substance can be broken down by a chemical change.

Examine Figure 5.11. It shows what happens when electricity is passed through water. The electricity causes a chemical change. As a result of this change, the water is broken down into two different gases, hydrogen and oxygen.

Elements and Compounds

Can you also break down hydrogen and oxygen by a chemical change? No. Hydrogen and oxygen are examples of a group of pure substances called elements. An **element** is a pure substance that cannot be broken down or separated into other pure substances. Other examples of elements are sodium, chlorine, carbon, iron, potassium, aluminum, and helium.

Water is an example of a different group of pure substances called compounds. A **compound** is a substance that is made from two or more elements that have combined in a chemical change. For example, water is made by combining the elements hydrogen and oxygen.

There are millions of compounds in the world. Each compound is a different combination of two or more elements. Salt and sugar are two common examples of compounds. Salt is made from the elements sodium and chlorine. Sugar is made from the elements carbon, hydrogen, and oxygen. Figure 5.12 shows two different compounds that are made from carbon and hydrogen.

Off the Wall

The properties of compounds are generally very different from the properties of the elements that formed them. For example, sodium is a dangerously reactive metal. Chlorine is a poisonous gas. Yet these two elements combine to produce a substance that you and most other living things need to survive: salt!

Figure 5.12 Propane is a gas that is used in barbecue tanks (A). Paraffin wax is a solid that is used to make candles (B). Both of these compounds contain only hydrogen and carbon.

Find Out **ACTIVITY 5-F**

An Element and a Compound

Gold and copper are found as pure elements in Earth's crust. Most other metals, such as iron and aluminum, are not found as pure elements in nature. Instead, they are found combined with other elements in compounds. You are going to investigate how one element, iron, forms a compound.

Safety Precautions

Wash your hands thoroughly after this activity. Dispose of the materials as instructed by your teacher.

What You Need

1 iron nail (plus one more for scraping)
magnet
plastic wrap
jar
tap water
piece of white cardboard

What to Do

1. **Observe** one of the iron nails. **Record** your observations.
2. Obtain a magnet. Wrap your magnet in plastic wrap to keep it clean.
3. Through the cardboard, test the nail with the magnet. **Record** your observations.
4. Place the nail in a jar with a little salty water. Allow the nail to sit for a few days.
5. Remove the nail from the water. **Record** your observations.
6. Use the second iron nail to rub the rusted nail gently, over a piece of white cardboard. **Record** your observations.
7. Hold up the cardboard horizontally. Move the magnet back and forth under the cardboard. **Record** your observations.

What Did You Find Out?

1. How did the magnet affect the new iron nail? Is iron magnetic?
2. How did the nail change after it had been sitting in the water for several days?
3. What did you observe when you moved the magnet under the powder on the cardboard?
4. What evidence do you have that a chemical change occurred?

Is rusting a chemical change or a physical change?

Elements and the Periodic Table

There are 92 elements that exist naturally and 24 elements that can be made in a laboratory. Scientists have listed all these elements in a table called the **periodic table**. For simplicity, the periodic table in Figure 5.13 includes only some of the elements. The full periodic table looks very similar to this table, as you will see in later science courses. Each square in the periodic table represents one element, as in Figure 5.14.

Periodic Patterns

The elements in the periodic table are arranged in columns and rows. The columns are called *groups*. The rows are called *periods*. Elements that have similar properties are close to each other.

Take a look at the simplified periodic table in Figure 5.13.

- Place your finger on the first row. Name the elements in this period.
- Run your finger down the eleventh column. List the elements in this group.
- Find the spot where the fourth row (period) and the seventh column (group) meet. What element is there?

INTERNET CONNECT

www.mcgrawhill.ca/links/BCscience7

To learn more about elements, go to the web site above. Click on **Web Links** to find out where to go next.

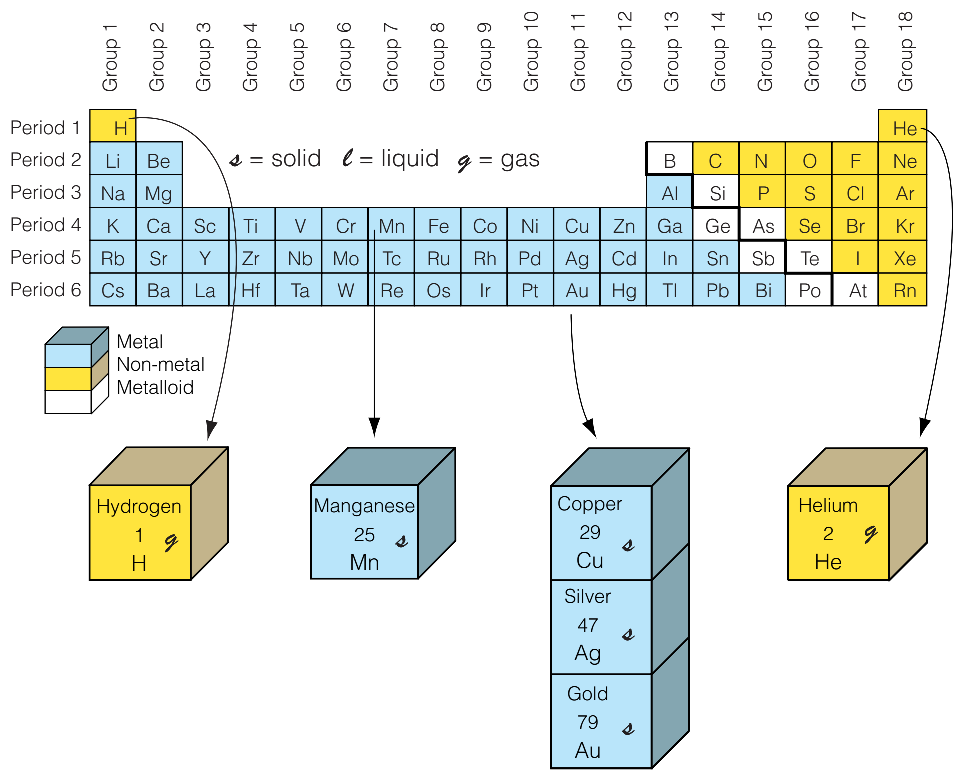


Figure 5.13 The elements are arranged in order across periods, starting with hydrogen. Thus, hydrogen (H) is element number 1. Lithium (Li) is element number 3. What number is beryllium (Be)?

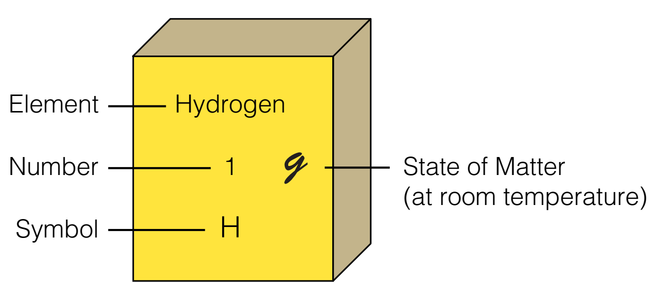


Figure 5.14 Each element has a name, symbol, and number. Oxygen has the symbol O. It is element number 8. Detailed periodic tables are a valuable source of information about elements and their properties.

READING Check

Define “element” using Dalton’s atomic theory.

Explaining Elements and Compounds

How can you explain the differences between elements and compounds using the particle model? Go back to page 144. The particle model of matter states that the particles of a pure substance are the same. It does not tell you what the particles are like. Finding out what the particles are like is key to explaining why elements and compounds are different. There is one problem, however. The particles are far too small to see!

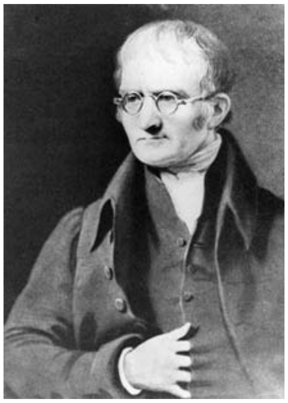


Figure 5.15 John Dalton developed a theory about matter that is still useful today.

Beyond the Particle Model of Matter

John Dalton (1766–1844), shown in Figure 5.15, was an English teacher and a scholar. In 1808, he introduced a new model of matter. He used his model to develop a theory. A **theory** is an explanation that scientists develop after completing many experiments. Scientists develop theories to explain their observations. Dalton developed his theory as a way to explain the observations about matter that he and other scientists had made. He needed to theorize because he could not actually see the structure of matter.

Dalton’s Atomic Theory

- All matter is made of small particles, called **atoms.**
- Atoms cannot be created, destroyed, or divided into smaller particles.
- All atoms of the same element are identical. They have the same mass and size. They are different in mass and size from the atoms of other elements.
- Compounds contain atoms of different elements in definite proportions or ratios.

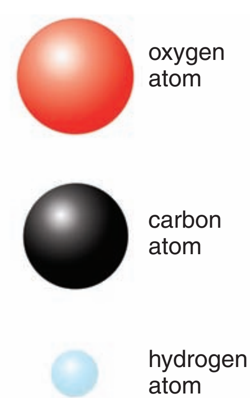


Figure 5.16 These models show that a carbon atom is bigger than a hydrogen atom but smaller than an oxygen atom.

Go back to page 145 to review the definition of an element. Dalton’s theory provides a different way to define an element. According to Dalton’s theory, an element is a pure substance that is made up of only one type of atom. As well, the atoms in an element cannot be changed, destroyed, or divided. So, Dalton’s theory helps to explain why you cannot use a chemical change to get simpler substances from an element. The models of atoms in Figure 5.16 help to illustrate Dalton’s theory. Note that the colours are used to help you identify the elements. An oxygen atom is not actually red, and a carbon atom is not actually black. Remember, atoms are millions and millions and millions of times smaller than these models.

Molecules

Dalton theorized that compounds are composed of fixed ratios of elements. For example, water contains fixed ratios of hydrogen and oxygen. If you run electricity through water, you get hydrogen and water. You *always* get *twice* as much hydrogen by volume as oxygen. Hydrogen peroxide also contains hydrogen and oxygen, but in a different ratio. If you decompose hydrogen peroxide, you *always* get *equal* volumes of hydrogen and oxygen.

How is the idea of atoms useful for explaining why compounds contain elements in fixed ratios? Scientists theorize that atoms can link together. When two or more atoms link together, a **molecule** is formed. A molecule of water has two atoms of hydrogen (2 × H) and one atom of oxygen (1 × O). This is why water is sometimes written this way: H_2O. Similarly, a molecule of hydrogen peroxide contains two atoms of hydrogen and two atoms of oxygen (H_2O_2). A chemical change can break apart a water or hydrogen peroxide molecule, forming oxygen and hydrogen.

Four different compounds, and models of the molecules they are made from, are represented in Figures 5.17, 5.18, 5.19, and 5.20.

Dalton's theory and the theory that atoms can form molecules are sometimes grouped together and called the atomic-molecular theory.

DidYouKnow?

Theories are constantly changing. For example, scientists no longer believe that atoms are indestructible. In the late nineteenth century and early twentieth century, scientists found evidence that atoms are made up of still smaller particles. Scientists called these particles *electrons, protons,* and *neutrons.* Later in the twentieth century, scientists found evidence that even neutrons and protons are made up of smaller particles. Scientists believe that they still have a lot to learn about atoms.

Figure 5.17 Every water molecule consists of one oxygen atom and two hydrogen atoms.

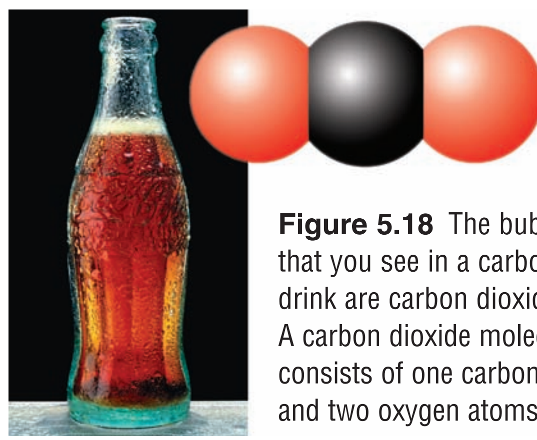
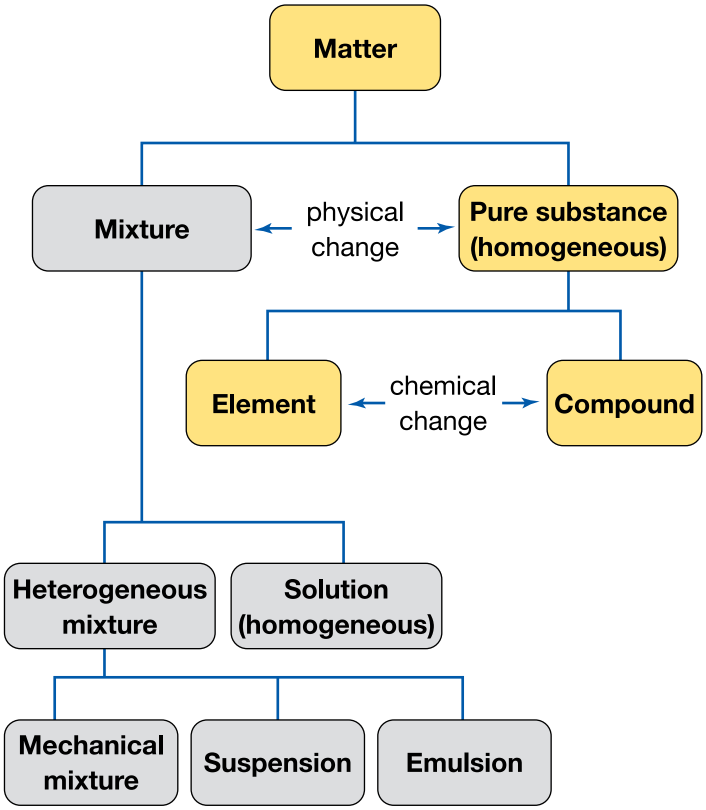


Figure 5.18 The bubbles that you see in a carbonated drink are carbon dioxide gas. A carbon dioxide molecule consists of one carbon atom and two oxygen atoms.

Figure 5.19 Some stoves burn natural gas to provide heat. Natural gas is mostly methane. Every methane molecule consists of one carbon atom and four hydrogen atoms.

Figure 5.20 Sucrose (white sugar) can be obtained from sugar cane. A sucrose molecule consists of 12 atoms of carbon, 22 atoms of hydrogen, and 11 atoms of oxygen.



Section 5.3 Summary

In this section, you classified pure substances as elements or compounds.

- An element cannot be broken down into simpler substances by a chemical change.
- Each element is made of a different kind of atom.
- The 116 known elements are listed in the periodic table.
- A molecule is made of more than one atom linked together.
- A compound is made of chemically combined elements.

The chart on the left shows how compounds and elements fit into the classification of matter. In section 5.4, you will learn how you can obtain useful materials, such as pure substances, from mixtures.

Key Terms

element
periodic table
compound
theory
atoms
molecule

Check Your Understanding

1. How can a chemical change help you tell the difference between an element and a compound?
2. Could you use a chemical change to obtain simpler substances from sodium? Explain your answer.
3. Both compounds and mixtures contain two or more elements. How are compounds different from mixtures?
4. **Apply** Atomic-molecular theory is a way to explain what the particles of the particle model of matter are like. For example, according to atomic-molecular theory, a particle of water is a water molecule made of two hydrogen atoms and one oxygen atom.
   (a) According to atomic-molecular theory, what is a particle of carbon?
   (b) According to atomic-molecular theory, what is a particle of white sugar (sucrose)?
5. **Thinking Critically** Both water and hydrogen peroxide contain hydrogen and oxygen. You can drink water, but hydrogen peroxide is poisonous. Why do these compounds have different properties?

Section 5.4

Pure Substances from Mixtures

You probably separate mixtures without even thinking about it. For example, you are separating a mixture when you sort coins based on their colours and sizes. You are separating a mixture when you drain pasta in a colander. Figure 5.21 shows how a washing machine separates a mixture. In the next activity, you will explore methods of separation.

Figure 5.21 The spin cycle on a washing machine separates the clothes from the water.

Find Out ACTIVITY 5-G

Separating Mixtures

What methods can you use to separate different mixtures? Decide how you would recover all the materials from each mixture, in their original form.

What You Need

10 containers of different mixtures, provided by your teacher
dictionary

Safety Precautions

Do not open the containers.

What to Do

Group Work

1. Make a table that is similar to the one below. Give your table a title.

Mixture	Separation method	Why the method works

2. **Observe** the mixtures. With your group, brainstorm possible methods that you could use to separate each mixture.

   For example, you could use:
   - filtration
   - sifting (using sieves)
   - magnetism
   - evaporation
   - flotation
   - dissolving

   You may think of other methods you could use. Look up any terms you do not know in a dictionary, and record their meanings.

3. Complete your table. Some mixtures may require more than one method. If a mixture contained marbles, sand, and small pieces of iron, for example, you could use sifting and then a magnet to separate the parts.

What Did You Find Out?

1. Which properties of pure substances did most of the methods involve?

2. Which methods of separation did you list most frequently?

3. (a) Which mixtures would be easier to separate? Why?
   (b) Which mixtures would be more difficult to separate? Why?

Career CONNECT

Checking Mixtures

Have you ever wondered what is in your milkshake or soft drink, or in the cleaner you use to wash the sink? You can be sure that a chemical research analyst knows. Chemical research analysts examine mixtures. They find out what pure substances are in a mixture to ensure that the mixture contains no harmful substances, such as pesticides.

John Persaud is a chemical research analyst. He works for a petrochemical company that makes products from crude oil, a natural mixture. John's job is to check the contents of these products before they are sold to consumers. He makes sure that the crude oil is good quality and contains no unwanted substances. In the laboratory, he tests samples of the products that are made from the crude oil, such as natural gas, motor oil, gasoline, and diesel fuel. If he finds unwanted substances, he develops ways to separate them from the batch.

John cannot possibly tell what a petrochemical product contains, just by looking at it. Specialized equipment and computers in the laboratory help him separate out all the different substances in the mixture. They also help him determine what the substances are.

John Persaud, a chemical research analyst

READING Check

Is gold a pure substance or a mixture? Is gold ore a pure substance or a mixture?

Solid Mixtures Underground

Most underground materials are solid—solid rocks. Most rocks are mixtures. For example, the rock shown in Figure 5.22 is a mixture of two pure substances: white-coloured quartzite and gold. This rock is called gold ore because it can be processed to get gold. An *ore* is a rock in the ground that contains one or more valuable substances. Gold ore is an example of a raw material. A **raw material** must be processed to obtain useful products.

The discovery of a large deposit of gold ore is exciting. Gold is valuable because it is beautiful and rare. It is also valuable because of its properties. Gold does not corrode easily, and it can be worked into jewellery because it is soft.

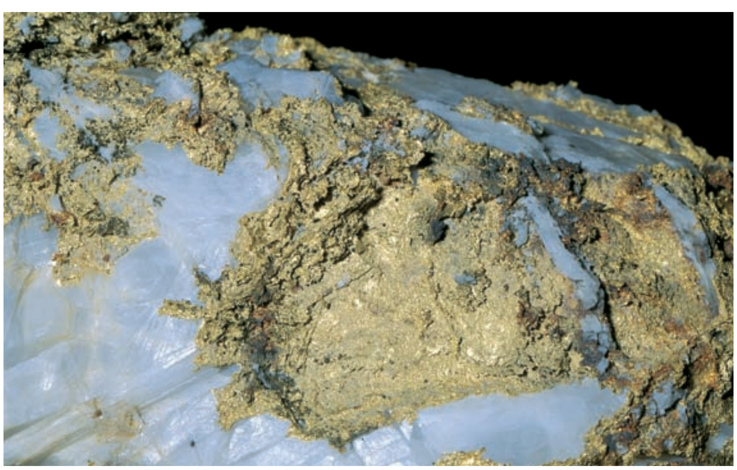


Figure 5.22 The white part of this rock is quartzite. The yellow part is nearly pure gold.

Gold is so valuable that people are willing to go to a lot of trouble to get it. In the nineteenth century, reports of newly discovered gold deposits led to gold rushes. The first gold rush in North America started in 1848 in California. There was another famous gold rush in Canada's Yukon Territory. British Columbia had its own gold rushes. The first was in 1858 on the Fraser River. The second was in 1862 in the Cariboo region.

The Cariboo Gold Rush

People came from all over the world for the chance to find gold in British Columbia. They travelled many kilometres by boat and foot to get to a Cariboo mining town, such as Barkerville, shown in Figure 5.23. There, they could stake their claim and start looking for gold.

The simplest way to find gold in streams was by panning. A miner dug out material from the stream bed and swirled it in a pan with plenty of water. Gold is a very dense element. Even tiny pieces of gold are have more mass than pieces of sand or gravel. As the miner swirled the mixture from the stream bed, the pieces of sand, gravel, and mud were washed away. If the miner was lucky, a nugget or two of pure gold would be left at the bottom of the pan. In the next activity, you will make a model to illustrate panning for gold.

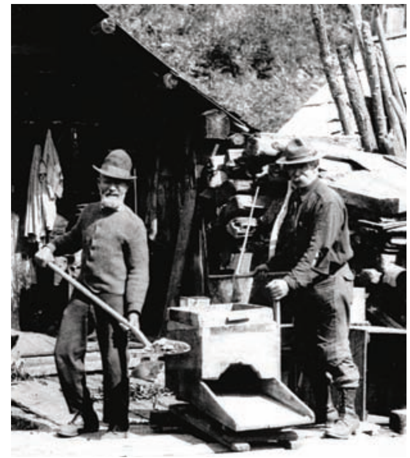


Figure 5.23 Barkerville was named after a miner named Billy Barker. Barker found enough gold in the creek nearby to make him very, very wealthy.

Find Out **ACTIVITY 5-H**

Panning for "Gold"

Make a working model to show how panning for gold works.

How does panning work?

What You Need

about 1 L Styrofoam™ packing "peanuts"
about 1 L marbles
large paper bag
large basin
hair dryer

Safety Precautions

Turn off the hair dryer when you are not using it.

What to Do

1. Pour the "peanuts" and marbles into the large paper bag, and mix them thoroughly.
2. Place the mixture in a large basin. Use a circular motion to swish and swirl the basin steadily. Have a partner aim a hair dryer across the top of the basin. Your partner should aim away from you for safety.

What Did You Find Out?

1. Identify which part of your model represents
   (a) gold nuggets
   (b) gravel
   (c) running water
2. **(a)** How is your model similar to the method that was used to pan for gold?
   (b) How is your model different from panning?

Section 5.4 Summary

In this section, you learned the following methods for separating mixtures:

- filtration
- sifting (using sieves)
- magnetism
- evaporation
- flotation
- dissolving
- panning

In Chapter 6, you will learn about more methods for separating solutions. You will also learn how some of these methods are used to purify one of our most important resources—water.

Key Terms

raw material

Check Your Understanding

1. Look at the list of separation methods above. Do these methods involve chemical changes or physical changes? How do you know?
2. A mixture contains marbles of three different sizes. How could you use two different sieves to separate the mixture? Draw diagrams to illustrate your method.
3. A mixture contains Styrofoam™ "peanuts" and marbles. What are two different ways to separate this mixture?
4. How would you separate each mixture below?
   (a) wood chips and pieces of granite rock
   (b) iron filings and dirt
   (c) salt and pepper
5. **Apply** The small pitcher shown here is used to separate fat from gravy juices.
   (a) What property of fat and gravy juices allows you to separate them?
   (b) The pitcher is designed so that gravy juices, not fat, pour out of the spout. Gravy juices are mostly water. Why does the spout come from the bottom of the pitcher?
   (c) If you were going to use the gravy shown in the photo, what would you do first? Explain.
   (d) If you did not have a gravy pitcher, how could you separate the fat from the gravy juices?
6. **Thinking Critically** Petroleum (also called crude oil) is a liquid mixture that is found underground. Petroleum is processed to make useful materials such as gasoline, jet fuel, waxes, and diesel oil.
   (a) How is petroleum similar to gold ore?
   (b) How is petroleum different from gold ore?

This pitcher allows you to enjoy gravy with less fat.

CHAPTER at a glance

Now that you have completed this chapter, try to do the following. If you cannot, go back to the sections indicated in brackets after each part.

(a) In your classroom, identify something made of a material that is heterogeneous. List the properties of each type of matter in the material. (5.1)

(b) In your classroom, identify something made of a material that might be homogeneous. Explain why you would need to investigate further to find out whether or not the material is homogeneous. (5.1)

(c) Brainstorm a list of ten foods and drinks that are mixtures. Classify each mixture as precisely as possible. (5.2)

(d) A mixture contains sand, iron filings, and wood chips. Draw a flowchart to show how you would separate this mixture. (5.3)

(e) How are mixtures and compounds the same? How are they different? (5.3)

(f) Draw an atom of oxygen and a molecule of water. How are these models different from real atoms and molecules? Why are models like these useful? (5.3)

(g) What mixture is the colander shown below designed to separate? What other methods for separating mixtures do you use in your daily life? (5.4)

(h) Why are natural materials often processed before they are used to make products? (5.4)

This colander is a type of sieve. How does it work?

Prepare Your Own Summary

Summarize this chapter by doing one of the following. Use a graphic organizer (such as a concept map), create a poster, or write a summary to include the key chapter ideas. Here are a few ideas to use as a guide:

- Illustrate some ways of telling whether or not a substance is a mixture.
- List some ways to identify a pure substance.
- Create a poster to explain the difference between elements and compounds.
- Create flowcharts to show methods for separating different mixtures. What method is shown in the photograph below?

CHAPTER 5

Review

Key Terms

mixture
heterogeneous
pure substance
homogeneous
mechanical mixtures
suspension
emulsion
solutions
alloys
dissolves
solute
solvent
element
periodic table
compound
theory
atoms
molecule
raw material

Reviewing Key Terms

If you need to review, the section numbers show you where these terms were introduced.

1. In your notebook, match each description in column A with the correct term in column B. Use each description only once.

Column A

(a) Dalton's theory says they cannot be destroyed
(b) type of matter that is made of only one kind of atom
(c) type of matter that cannot be separated by physical changes
(d) type of matter that must be processed before being used
(e) mixture such as paint
(f) pizza is an example
(g) another name for salt when it is dissolved in water
(h) particle that is made of two or more atoms linked together

Column B

- pure substance (5.1)
- mechanical mixture (5.2)
- suspension (5.2)
- emulsion (5.2)
- solute (5.2)
- solvent (5.2)
- elements (5.3)
- atoms (5.3)
- molecules (5.3)
- compounds (5.3)
- raw materials (5.4)

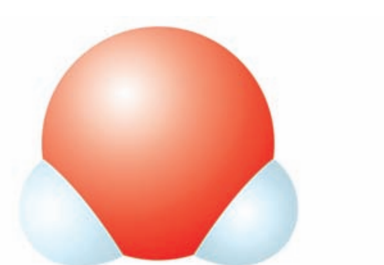
2. For each of the following, what is the relationship between the two terms?
(a) pure substance, homogeneous (5.1)
(b) solution, homogeneous (5.2)
(c) mixture, solution (5.2)
(d) suspension, emulsion (5.2)
(e) mechanical mixture, properties (5.2)
(f) element, atom (5.3)
(g) compound, element (5.3)
(h) atom, molecule (5.3)
(i) theory, atom (5.3)
(j) raw material, mixture (5.4)

Understanding Key Ideas

Section numbers are provided if you need to review.

3. The properties of a sample of matter can help you decide whether the material is homogeneous or heterogeneous. (5.1)
(a) What is an example of matter that is clearly heterogeneous?
(b) What is an example of matter that is clearly homogeneous?
(c) Easily observed properties can be misleading. What is an example of a material that looks homogeneous but is actually heterogeneous?

4. Examine the model below. (5.3)
(a) What does the model represent?
(b) How is this model useful?
(c) How does the model differ from the thing it represents?



5. How would you define the terms "mixture" and "pure substance?" Use ideas from the particle model of matter in your definitions. Give two examples for each definition. (5.1)

Developing Skills

6. How does panning separate gold from gravel? Draw a diagram to help explain.

7. How would you separate each mixture below? Outline your method in a flowchart.
   (a) oil and water
   (b) paper clips and pennies
   (c) sawdust and sugar

8. Models are useful when you are visualizing molecules.
   (a) How could you use Styrofoam™ balls and toothpicks to make models of molecules?
   (b) How would your models be better than the two-dimensional models in this textbook?
   (c) Would there be any drawbacks to your models? Explain.

Problem Solving

9. A liquid that looks like water boils at 106°C.
   (a) Is the liquid pure water? Explain how you know.
   (b) How could you change the boiling temperature of pure water but not its appearance?

10. Suppose that your friend gives you a bracelet that she says is pure copper. You decide to find out for yourself. Using a balance, you find that the mass of the bracelet is 30 g. Using displacement, you find that its volume is 3.5 mL. Is the bracelet made of pure copper? Explain your answer. (Hint: You will need to refer to Table 4.3 on page 119.)

Critical Thinking

11. One type of iron ore is composed of rock and a compound called magnetite. Magnetite is made from the elements iron and oxygen.
   (a) Magnetite is a magnetic compound. How could you separate magnetite from the rock it is mixed with?
   (b) Once you have pure magnetite, can you use physical changes to get pure iron? Explain your answer.
   (c) Magnetite and iron share the property of magnetism. How are they different?
   (d) How is iron ore different from gold ore? Explain your answer.

Magnetite

Pause & Reflect

Go back to the beginning of this chapter on page 130, and check your original answers to the Getting Ready questions. How has your thinking changed? How would you answer these questions now that you have investigated the topics in this chapter?