UNIT C

Pure Substances and Mixtures

Unit Overview

A technician (lower right) watches over processes using pure substances and mixtures in a factory producing health products.

Fundamental Concepts

In Science and Technology for grades7 and 8, six fundamental concepts occur throughout. This unit addresses the following two:

- Matter
- Systems and Interactions

Big Ideas

As you work through this unit, you will develop a deeper understanding of the following big ideas:

- Matter can be classified according to its physical characteristics.
- The particle theory of matter helps to explain the physical characteristics of matter.
- Pure substances and mixtures have an impact on society and the environment.
- Understanding the characteristics of matter allows us to make informed choices about how we use it.

Overall Expectations

By the end of this unit, you will be expected to:

1. evaluate the social and environmental impacts of the use and disposal of pure substances and mixtures
2. investigate the properties and applications of pure substances and mixtures
3. demonstrate an understanding of the properties of pure substances and mixtures, and describe these characteristics using the particle theory

Exploring

Maple sap is boiled over an open fire to concentrate it.

Maple syrup production requires the separation of water from maple sap, which leaves behind a more concentrated mixture of sugar. According to historians, members of the Algonquin First Nation may have discovered the nutritional properties of maple sap. They made V-shaped cuts in sugar maple trees and collected the sap in birchbark containers. In time, many First Nations peoples, including the Algonquins, boiled the collected maple sap in clay pots over an open fire to concentrate the maple syrup, similar to what is shown in the above photo.

Sharing Technology

First Nations peoples showed French settlers how to tap maple trees in the spring to collect sap. These settlers used metal drills to bore into the trunks of maple trees so that they could

insert homemade taps into the trees. They would then hang wooden buckets on the taps to collect the sap, as shown in the photo to the right.

Maple syrup production became an important part of the lives of 16th- and 17th-century settlers. To improve the efficiency of the boiling process, iron and copper kettles containing sap were suspended over fire pits. However, much of the heat from burning wood was able to escape. To reduce this heat loss, boiling of sap was moved indoors. Sugar shacks were built to block the wind and contain the heat from the fires. Also, the sugar shack's walls and roof helped to reduce contamination of the boiling sap by leaves and insects.

Early settlers collected sap in wooden buckets.

Impact of Technology

Over the next two centuries, innovations involved containing the heat in more efficient boilers. Sheet metal was fashioned into large, flat evaporators and fire boxes that contained the heat, increasing the surface area of the boiling sap. However, producing 1 L of maple syrup meant that 40 L of sap had to be carried to the evaporator, which made the process very labour intensive.

In the 20th century, the efficiency of maple sap collection for syrup production was greatly enhanced. Trees were tapped and connected to hoses, which allowed the sap to run downhill to collecting tanks or the evaporators in sugar shacks. Later, vacuum pumps were used to increase the amount of sap collected from each maple tree, as shown in the photo to the right.

Evaporator technology has also improved. Raw sap flows or is pumped into a large, relatively deep pan to begin the boiling process. As water is removed, the more concentrated mixture flows into a smaller, shallower pan. Here it is concentrated further. Finally, the more concentrated mixture flows into a third, very shallow pan, where boiling is managed to enable precise control of the sugar content of the syrup.

Maple sap is collected using pipelines connected to a vacuum pump.

...MORE TO EXPLORE

C1 Quick Lab

Concentrating a Mixture — A Simulation

Maple syrup is made by boiling a maple sap mixture to remove the water. In this activity, you will simulate that process with sand and marbles, where sand represents the water and marbles represent the sugar.

Purpose

To simulate the concentration of a mixture

Materials & Equipment

- 100-mL beaker (jar)
- sand
- marbles
- balance

Procedure

1. Measure and record the mass of an empty beaker.
2. Place marbles in the beaker. Measure the mass of the beaker and marbles. Subtract the mass of the beaker, and then record the mass of the marbles in a table as shown to the right.
3. Fill the beaker with sand. Measure the mass of the full beaker. Subtract the mass of the beaker and marbles, and then record the mass of the sand.
4. Remove some sand, then measure the mass of the beaker. Repeat this process two more times.

Table C.1 Comparing the concentration of different mixtures

Mass of Beaker (g)	Mass of Marbles (g)	Mass of Sand (g)	Mass of Marbles Divided by Mass of Sand

Questions

5. How does the concentration of marbles in the mixture change as sand is removed?
6. How does the ratio of mass of marbles to mass of sand change as sand is removed?
7. Explain how this simulation relates to concentration of maple syrup.

C2 Thinking about Science, Technology, Society, and the Environment

Environmental Impact of Maple Syrup Production

1. Make a list of both positive and negative effects of the production of maple syrup on society and the environment.
2. With a classmate or the whole class, discuss the significance of each effect mentioned above.
3. Based on your discussions of positive and negative effects, should we be producing maple syrup? Support your answer.

UNIT C

Contents

Unit Task

Many sources of water contain mixtures of naturally occurring substances and contaminants. In your unit task, you will investigate water samples taken from a number of surface water sources. You will use skills that you learn in this unit to purify the water samples. You will also be able to identify possible sources of contaminants from the sample.

Essential Question

What are some industrial and commercial sources of pure substances and mixtures that mix with surface water to make it impure?

Getting Ready to Read

Thinking Literacy

Probable Passage

You will be introduced to the following terms in this unit:

- pure substance
- mixture
- concentration
- solution
- particles

Which of these terms can you already define? Which of these terms are you unsure of? Based on what you already know, write one or two sentences that make a prediction about what you will learn in this unit.

7.0 The particle theory of matter can be used to describe pure substances and mixtures.

Pure substances combine into a mixture to eventually become bread.

What You Will Learn

In this chapter, you will:

- distinguish between pure substances and mixtures
- state the points of the particle theory of matter
- use the particle theory to describe the difference between pure substances and mixtures

Skills You Will Use

In this chapter, you will:

- use appropriate science and technology vocabulary in oral and written communications
- follow established safety procedures for handling chemicals and apparatus

Why This Is Important

Everything that you see, touch, taste, and smell is made of particles. Your body is a complex mixture of particles that is maintained by eating nutritious foods, which are also made up of particles.

Before Reading

Thinking Literacy

Making Predictions

Making predictions before reading helps you to activate your prior knowledge and to anticipate what you will learn. Before reading this chapter, look at the headings and captions in the text. Record this information in a chart, along with your thoughts about what you will find out. Revisit your predictions during the chapter to confirm or revise your understanding of the topic.

Key Terms

- heat
- kinetic energy
- mechanical mixture
- mixture
- particle
- pure substance
- solution
- temperature

7.0 Getting Started

Figure 7.1 Crude oil is a mixture of pure substances that sticks to everything it contacts, creating a mess that is difficult to clean up.

When crude oil spills into a natural environment, such as from a damaged oil tanker at sea or a broken pipeline on land, the result is a sticky black mess. Everything in the immediate environment is changed by the contamination caused by the spill.

In July 2007, a crude oil pipeline was accidentally broken in Burnaby, British Columbia (Figure 7.1). More than 240 000 L of crude oil was released into the environment. The oily black mixture contaminated a residential area and eventually flowed into the Pacific Ocean.

City residents reported that their lawns and gardens were coated with oil. Environmental experts determined that soil and ground water chemistry would be damaged, perhaps for a very long time. Also, birds, mammals, and marine wildlife would be severely injured, and some would die. Many people wondered how the oil could be separated from the water, soil, plants, and animals.

Understanding the properties of the substances that make up this oily mixture was essential to the clean-up effort. By studying the properties of substances, environmental experts can find new methods to treat environmental contamination (Figure 7.2).

You will also want to learn how to use substances. You may want to build a model with special glue, apply a styling product to your hair, or clean the mud off your bike. To do this, you will need to understand some key ideas about substances. In this chapter, you will study the points from the particle theory of matter and use them to classify substances.

Figure 7.2 Studying the properties of substances can help to save wildlife, such as this sea otter, from environmental contamination.

C3 Quick Lab

Animal, Plant, or Mineral

Although you may not give it much thought, you make classification decisions all of the time. Cars, music, and the food you eat are classified into categories to make it easier to understand, obtain, or use these items. In this activity, you will make some decisions about the categories of some items found in your classroom.

Purpose

To classify items found in your classroom as animal, plant, or mineral

Materials & Equipment

- paper
- pen or pencil
- magnet (optional)

Procedure

1. Make a copy of the following table with enough space for 10 items.

Table 7.1 Animal, plant, or mineral

Item	Animal	Plant	Mineral
pencil	no	yes	yes

2. Select 10 items found in your classroom. With a partner, decide if any part of each item is made up of something that is or comes from animals, plants, or minerals (e.g., metals, plastics).
3. Complete your table and then answer the following questions.

Questions

4. Is it always easy to determine what something is made from? Be sure to explain your answer thoroughly with at least one example.
5. Do some of the items belong to more than one category? Provide an example of an item that belongs to two or three categories.
6. Sometimes items do not fit conveniently into categories because the categories may not provide enough information or choice. Think of other categories that could be used to classify items in the classroom. Explain how you would use this category in a classification system.

7.1 Classification of Matter by Composition

Here is a summary of what you will learn in this section:

- Everything that we see is made up of matter.
- Matter can be classified as a pure substance or a mixture.
- Mixtures can be classified as solutions or mechanical mixtures.

Figure 7.3 Chocolate chip cookies and milk are made of matter.

Chocolate chip cookies, milk, the glass holding the milk, the plate under the cookies, and the air you breathe have something in common (Figure 7.3). They are all made of matter. **Matter** is anything that has mass and takes up space. Mass is the amount of matter in an object.

You may already know that matter can be classified by its physical state: solid, liquid, or gas. A **solid** is matter that has a definite shape and volume. Volume is the amount of space that matter occupies. Textbooks, trees, cars, and running shoes are all made up of solid matter. A **liquid** is matter that does not have a definite shape but does have a definite volume. A liquid takes the shape of its container. Rainwater, orange juice, mouthwash, and gasoline are all made up of liquid matter. A **gas** is matter that does not have a definite shape or volume. Air is made up of different types of gaseous matter, such as oxygen and nitrogen. You can also use an understanding of what makes up matter to classify substances by composition.

C4 Starting Point

Skills A C

Classify This

Look for similarities and differences in the physical appearance of 5 to 10 common substances (e.g., bread, juice, chocolate bar, butter, cereal). Come up with your own classification system, and provide reasons for how you classified each substance. Prepare a table like the one shown to record your reasons. Give your table a descriptive title.

Table 7.2 Classifying substances

Substance	Classification	Reasons for Your Classification
Milk	Liquid	Milk is a liquid.

Classifying Matter by Composition

Matter can be grouped in different ways. It can be classified as a solid, a liquid, or a gas. All matter can also be grouped into two basic categories: pure substances and mixtures.

Pure Substances

A **pure substance** is made up of only one type of matter. Sugar, distilled water, and copper wire are all types of pure substances. Figure 7.4 shows that all the parts of the packet of sugar are the same. Similarly, all the parts of distilled water are the same, and all the parts of copper wire are the same. A pure substance is the same throughout and has the same properties throughout.

Pure substances appear uniform, or **homogeneous** [pronounced "hoh-moh-JEEN-ee-uhs"], throughout. This means that every part of that substance has the same composition as every other part. When you look at a container of salt or a glass of distilled water, every part of that substance looks the same.

Figure 7.4 All the parts in the packet of sugar are the same.

WORDS MATTER

The prefix "homo" comes from the Greek word "homos," which means "same."

Take It Further

Think of a common product found in a grocery store. Determine if its ingredients are pure substances or mixtures. Begin your search at ScienceSource.

Mixtures

A **mixture** is made up of two or more different substances. For example, pizza is a mixture of different types of edible ingredients placed on a flat dough that is baked in an oven (Figure 7.5). The dough is also a mixture of different substances, such as flour, eggs, and water. Many soft drinks are mixtures that may contain the pure substances carbon dioxide and sugar mixed with water.

Each substance in a mixture keeps its particular properties, even though those properties may be difficult to identify. For example, when you look at a bowl of salad, you can see the different vegetables in the mixture, and you can taste the oil and vinegar in the salad dressing. However, when you pour a soft drink into a glass, you cannot see the sugar in the mixture, although you can probably taste the sweetness of the sugar.

Figure 7.5 This pizza is a mixture of different ingredients.

Thinking Literacy

A Hypothesis Is a Prediction

The idea of making an "educated guess" based on prior knowledge is referred to by different names in different subject areas. In science, it is called hypothesizing.

In the Inquiry Activity on the following page, you are asked to consider which of the common substances in the following list are pure substances and which are mixtures: aluminum foil, baking soda, water, salt, sugar, vinegar, olive oil, baking flour.

Think about what you already know or have just learned about pure substances and mixtures, as well as what you know about each of the common substances. Based on this knowledge, predict whether each substance is pure or a mixture. Briefly explain why you think so. You have now developed a hypothesis for science.

Figure 7.6 The snack food is a mechanical mixture of different substances.

WORDS MATTER

The prefix "hetero" comes from the Greek word "heteros," which means "different."

Figure 7.7 Sweetened tea is a solution of sugar and different chemicals extracted from tea leaves.

Classifying Mixtures

Mixtures can also be grouped into two basic categories: mechanical mixtures and solutions.

When you look at **mechanical mixtures** closely, they do not have the same appearance throughout. They are **heterogeneous** [pronounced "het-uhr-oh-JEEN-ee-us"]. You can see the differences with the naked eye. There are differing amounts of different types of matter throughout the mixture. Snack food is an example of a mechanical mixture, as it contains different substances (Figure 7.6). Mechanical mixtures are also called **heterogeneous mixtures**. This means that they are made up of many different substances, each with different appearances and properties.

Solutions have the same appearance throughout, but are made up of two or more substances. When you mix one substance in another to form a solution, you **dissolve** one substance in the other. All solutions are **homogeneous mixtures** because they look the same throughout even though they are made up of different substances. For example, when you dissolve sugar in tea, the tea still looks the same throughout (Figure 7.7).

SKILLS YOU WILL USE
- Recording and organizing data
- Drawing conclusions

Classifying Substances by Composition

Figure 7.8 Looking closely at a substance can help you determine if it is a pure substance or a mixture.

Everything around you is made up of matter, including the food you eat, the air you breathe, and the liquids you drink. You will investigate the properties of common substances. Referring to these properties, you will classify each substance as either a pure substance or a mixture.

Question

Which of these common substances are pure substances, and which of them are mixtures?

Materials & Equipment

- common substances (e.g., aluminum foil, baking soda, water, salt, sugar, vinegar, olive oil, baking flour)
- hand lens (optional)
- microscope (optional)

CAUTION: Handle all substances as instructed by your teacher.

Procedure

1. Prepare a table like the one shown below to record your observations.

Table 7.3 Classifying substances by composition

Substance	Appearance	Pure Substance or Mixture
salt	white, granular	pure substance

2. Inspect each of the substances provided by your teacher. Note the appearance, using terms similar to the example. Relying on your observations and any other information available, classify each substance as a pure substance or a mixture of substances.
3. Return all substances and clean up your work area as instructed by your teacher. Wash your hands after the activity.

Analyzing and Interpreting

4. How did you determine if a substance was a mixture of more than one substance?
5. Was it possible to determine if a substance was pure just by its appearance? Please explain your answer.

Skill Builder

6. What findings did you use to draw the conclusions that you made?

Forming Conclusions

7. What must someone know about a substance in order to classify it as a pure substance?

7.1 CHECK and REFLECT

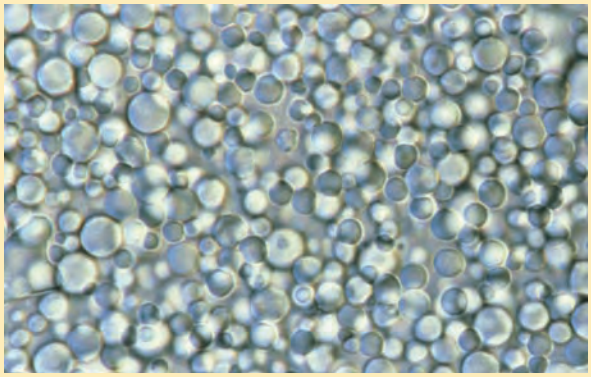
Key Concept Review

1. Explain the difference in appearance between a pure substance and a mixture.
2. How do the components of a mixture differ from the components of a pure substance?
3. What are the differences between sand and potting soil? Are they both mixtures? How do you know?
4. What are the key differences between solutions and mechanical mixtures? Give two examples of each.
5. Categorize each item as either a pure substance or a mixture.
   (a) chocolate pudding
   (b) gold necklace
   (c) bleach
   (d) helium gas
   (e) unfiltered tap water

Connect Your Understanding

6. Many hockey sticks are made of composite materials instead of wood. How would you classify each type of hockey stick?
7. Explain why most foods and beverages are mixtures.

Practise Your Skills



8. The above photo is a microscopic view of homogenized milk. Determine if homogenized milk is a mechanical mixture or a solution. Explain your answer.

For more questions, go to ScienceSource.

C7 *Thinking about Science and Technology*

Classifying Common Substances

At the beginning of this chapter, you created your own classification system to categorize common substances. This time, use the classification of matter flowchart to classify 5 to 10 common substances used in your home (Figure 7.9). Explain how each substance is commonly used.

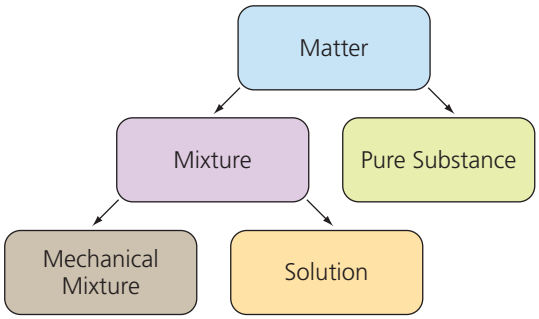


Figure 7.9 Standard classification diagram

7.2 The Particle Theory of Matter

Here is a summary of what you will learn in this section:

- The particle theory of matter describes the characteristics of matter.
- The spaces between particles are small in solids, larger in liquids, and largest in gases.
- Energy changes accompany changes of state.

Everything that you can see (e.g., cereal, milk), as well as everything that you cannot see (e.g., air, carbon dioxide), is made up of particles. **Particles** are very small portions of matter. These particles are so small that you cannot see them with your eyes alone. For example, a balloon is made up of particles (Figure 7.10). So is the air in the balloon. As the balloon fills with air, it expands. Air particles bump into each other and the balloon particles, which causes the balloon to inflate. If the balloon is filled with too many air particles, it will burst.

Figure 7.10 You cannot see the air particles in a balloon, but this student might feel their effects.

C8 *Starting Point*

Skills P C

Sugar Cubes and Particles

Because particles are so small, you cannot see them. A sugar cube can give you a better understanding of particles. You can see the granules that make up the sugar cube.

Work with a partner. Obtain a sugar cube and a small piece of plastic wrap from your teacher. Use the plastic to wrap the sugar cube securely. Place the wrapped sugar cube on a desk, and then gently tap the sugar cube until it breaks apart. Observe what happens

Discuss the following questions with your partner, and be prepared to share your ideas with the class.

Consider This

1. What are the similarities between the granules of sugar and particles?
2. When you hit the sugar cube, you must have done something to break it apart. What do you think you did to the sugar granules when you hit the sugar cube?
3. If all of the sugar granules were present after you hit the sugar cube, do you think they take up the same amount of space, less space, or more space than when the granules were arranged in the cube?

The Particle Theory of Matter

The **particle theory of matter** is a theory that describes matter. It explains the behaviour of solids, liquids, and gases.

1. All matter is made up of particles.
2. All particles of one substance are identical.
3. The particles of matter are in constant motion.
4. Temperature affects the speed at which particles move.
5. Particles have forces of attraction between them.
6. There are spaces between particles.

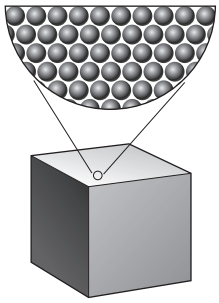


Figure 7.11 All matter is made up of particles.

Matter and Particles

All matter is made up of particles (Figure 7.11). Different substances are made up of different particles.

Particles of a pure substance are all identical. Figure 7.12 shows that substances A and B are both pure substances because each one is made up of only one type of particle. For example, distilled water is made up of water particles that are all the same. All the water particles look the same because they are the same. The particles that make up mixtures are different. Mixtures contain varying amounts of their component particles. For example, a soft drink consists of particles of sweetener, particles of flavouring, particles of water, and particles of gas (to make the bubbles).

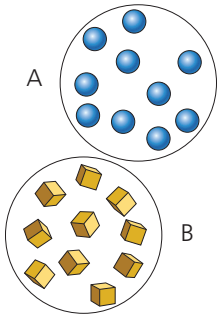


Figure 7.12 All particles of one substance are identical. A anb B are different substances.

Particles in Motion

The particles of matter are in constant motion (Figure 7.13). They move and vibrate constantly. "Vibrate" means to move back and forth rapidly. Particles move because they have kinetic energy. **Kinetic energy** is the energy of movement. In solids, the particles vibrate and wiggle in one place. In liquids, the particles slide around and over each other. The liquid takes the shape of the container. For each substance, its particles move more and have more kinetic energy when the substance is in a liquid state than when it is in a solid state. In gases, the particles move around as far as the space they are in allows, completely filling the space in the container. The particles of a substance move more and have more kinetic energy when the substance is in a gaseous state than when it is in a liquid state.

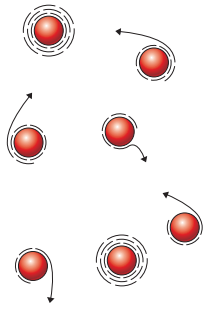


Figure 7.13 The particles of matter are in constant motion.

C9 Learning Checkpoint

Particle Theory — Points to Ponder

Use a single term from the list that follows to complete each of the sentences at right.

- different
- a mixture
- a pure substance
- identical

1. The particles of a pure substance are _____ .
2. The particles of a mixture are _____ .
3. The composition of most foods can be classified as _____ .
4. Oxygen and carbon dioxide are each classified as _____ .

Temperature, Heat, and Motion

To understand the speed at which particles move, you need first to understand the concepts of temperature and heat. **Temperature** is the measure of the average kinetic energy of the particles in a substance. It measures how hot a substance is. **Heat** is the energy that transfers from a substance at a higher temperature to one at a lower temperature.

Temperature affects the speed at which particles move (Figure 7.14). As you just learned, particles in matter are in constant motion. When heat transfers from a hotter substance to a cooler one, the particles in the cooler substance start to move faster.

You can observe the effects of this motion by placing a spoon in a cup of hot chocolate and feeling the temperature increase in the spoon's handle (Figure 7.15). Even though parts of the spoon are not in the hot chocolate, the whole spoon gets warmer. Heat in the hot chocolate is transferred to the particles in the spoon. The particles in the spoon then move faster; you sense this as an increase in the spoon's temperature. If you then place the spoon in a glass of cold water, the temperature of the spoon will decrease. The particles in the spoon then move slower because heat is transferred from the spoon to the colder water.

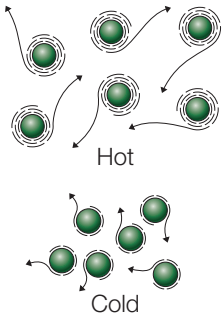


Figure 7.14 Temperature affects the speed at which particles move.

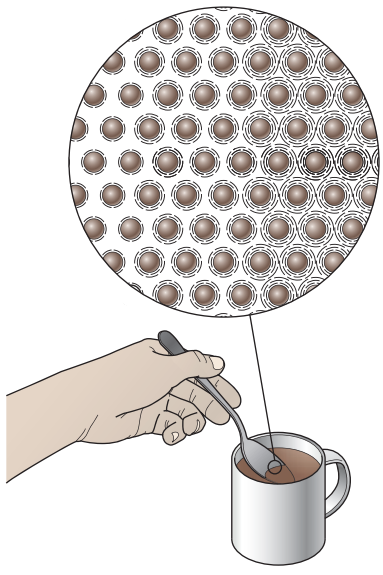


Figure 7.15 The particles of this spoon are moving faster because they are being heated by the hot chocolate.

Space and Attraction between Particles

There are spaces between particles. There are also forces of attraction between particles. Figure 7.16 illustrates how a substance has different amounts of space and attraction between particles when comparing that substance in its solid, liquid, and gaseous states.

Solid particles are much closer together and have greater attraction when compared to liquid particles. For example, the particles in a solid block of lead are closer together than the particles in a sample of lead that has been heated until it melts. Liquid particles are closer together and have greater attraction when compared to gas particles. For example, the particles in a glass of water are closer together and have greater attraction than the air particles in a balloon.

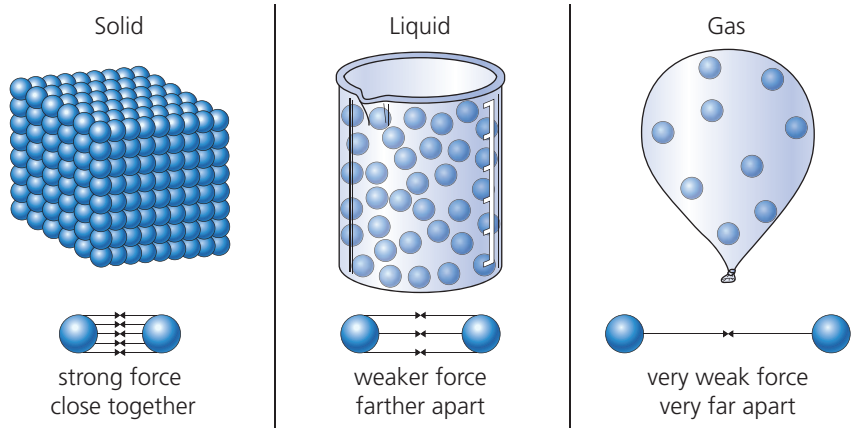


Figure 7.16 Particles have spaces and forces of attraction between them.

Temperature and Changes of State

Changes in temperature can also cause changes of state. A **change of state** is a change from one physical state of matter (solid, liquid, gas) to another. All matter exists as a solid, a liquid, or a gas. Changing the temperature of matter in one state can cause it to change to a different state. Figure 7.17, on the next page, shows how heat is necessary to overcome the degrees of attraction between particles of matter and result in a change of state.

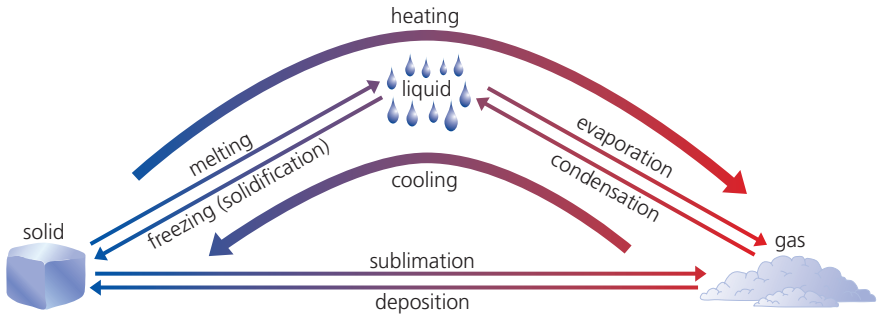


Figure 7.17 Energy is necessary to overcome the degrees of attraction between particles to change state from solid to liquid, liquid to gas, or directly from solid to gas. Energy is released when the substance changes state from gas to liquid, liquid to solid, or directly from gas to solid.

The change of state from a solid to a liquid is called **melting**. Heat must be added to make this happen. For example, think about a wax candle (Figure 7.18). Wax is a solid at room temperature. When the wick on the top of the wax candle burns, heat from the flame increases the temperature and melts the wax. The wax changes from solid to liquid.

The change of state from liquid to gas is called **evaporation**. Heat must also be added for this change of state to occur. When you boil water for a hot drink, you see steam rising from the surface of the water. This is water as a gas (vapour) evaporating from the liquid water.

The change of state from gas to liquid is called **condensation**. This change of state occurs when heat is removed. After you take a hot shower, you see water on the surface of the mirror in the bathroom. The mirror is cooler than the air so water vapour condenses from a gas to a liquid on the mirror.

The change of state from liquid to solid is called **freezing** or **solidification**. Liquid candle wax will solidify after a candle is extinguished and allowed to cool. Heat is removed, causing a decrease in the temperature of the wax so it solidifies.

The change of state from solid to gas is called **sublimation**. The change of state from gas to solid is called **deposition**. In both cases, there is no change to a liquid state. A change of state from solid to gas would occur when heat is added. You can see this in the spring sometimes. On a warm sunny day, some of the snow seems to disappear without melting. The solid water (snow) is changing directly to gas (vapour). A change of state from gas to solid would occur when heat is removed.

Figure 7.18 The wax in the candle changes state with changes in temperature.

Suggested Activity
C11 Inquiry Activity on page 205

Take It Further

Sublimation is a change of state that receives little attention. For example, ice cubes left for more than a week in the freezer will shrink noticeably. Think about why this happens and where the water goes. Begin your search at ScienceSource.

C10 *Inquiry Activity* Toolkit 2

SKILLS YOU WILL USE
- Asking questions
- Evaluating procedures

Acting Out the Particle Theory

It may be difficult to imagine how particles look when they are in solid, liquid, and gaseous form. Being able to see how they are arranged and move can give you a better understanding of particles. In this activity, you and your classmates will act like particles in the three states of matter.

Question

How can you and your classmates move and arrange yourselves to act like the particles that make up solids, liquids, and gases?

Materials & Equipment

- sheet of paper
- pen or pencil

Procedure

1. You will work in groups. Each group will work in a separate area. Treat each separate area as if it were a large container.
2. With your group, develop a way to represent a solid state of matter. Decide how to arrange yourselves and how to move to be particles of a solid.
3. Imagine that heat is being added to you. Your solid group changes positions and movements to represent liquid particles.
4. Now add more heat. Change your positions and movements again to represent gas particles.
5. Keep working together until your group is satisfied with the way you represent particles in the three states of matter. Then present one of these states to the rest of the class without saying what it is. Show yourselves changing from that state to another state (e.g., from a solid to a liquid).
6. Draw two rectangles on a sheet of paper. The rectangles represent "containers." Use them to sketch the two states of matter your group represented. Draw arrows to show your movement. Include other information about the way and the speed that you (as particles) were moving.

Analyzing and Interpreting

7. As a class, judge each group's presentation based on the following criteria:
   - How easy was it to infer the state of matter being represented? What were the best clues? How accurately did the group represent the state of matter?
   - How well did the group's actions represent the level of kinetic energy of the particles? How accurate was this action?
   - How well did the group's actions show changes in volume?

Skill Builder

8. What criteria did you use to evaluate and decide upon a method of representing states of matter?

Forming Conclusions

9. Review the scores that you gave your classmates' presentations. Write three paragraphs that describe the best presentation for each state of matter: solid, liquid, and gas.

SKILLS YOU WILL USE
- Using appropriate equipment and tools
- Drawing conclusions

Melting and Freezing of Deodorizer Blocks

The deodorizer blocks found in washrooms, like all other matter, are composed of particles. You will closely observe the melting and freezing of samples of a deodorizer block. You will not be able to see the tiny particles, but you can imagine what they are doing inside the test tube.

Question

What happens to the particles of a sample of deodorizer block when it melts and freezes?

Materials & Equipment

- 5-mL sample of deodorizer block
  OR
- 5-mL sample of salol (alternative to deodorizer block)
- test tube with stopper
- 50°C water bath

CAUTION: Do not eat or drink anything during this activity. Wash your hands thoroughly when you have finished the Procedure steps (after step 6).

Procedure

Part 1 — Melting a Sample of Deodorizer Block

1. Obtain a sample of 5 mL of deodorizer block, a test tube, and a stopper. Be careful to hold the test tube securely with your fingers on the glass rim.
2. Observe the sample very carefully and make a note of its appearance in your notebook (e.g., white crystals resembling ice).
3. Place the sample in the test tube and place the stopper loosely in the tube. Mark your test tube as instructed by your teacher.
4. Place the test tube in the warm water bath. In your notebook, describe what happens to the crystals.

Part 2 — Freezing a Sample of Deodorizer Block

5. Remove the test tube from the warm water bath by holding on to the rim at the top of the tube. **Do not hold onto the stopper.**
6. Hold the test tube upright in your hands. Note the appearance of the sample and any change of state.

Analyzing and Interpreting

7. What happened to the crystals when placed in the water bath?
8. What happened to the liquid when removed from the water bath?
9. Did the test tube feel cold when the liquid sample froze?

Skill Builder

10. What information will you use to draw conclusions in this experiment?

Forming Conclusions

11. What happened to the particles of the deodorizer block sample during the change of state from solid to liquid?
12. What happened to the forces between particles during the change of state from liquid to solid?

7.2 CHECK and REFLECT

Key Concept Review

1. Explain why a solid substance occupies less space than the same substance in gaseous form.
2. Explain why the particles of a liquid are able to pour into a container and then take on the shape of that container.
3. Explain what happens to the particles of a substance that changes state from liquid to gas.
4. Explain why ice cubes placed in your refrigerator's freezer section become smaller over time.

Connect Your Understanding

5. Use the particle theory of matter to explain how the particles in an ice cube differ from the particles in a glass of water.
6. Use the particle theory of matter to explain what happens to the particles in a hot drink when it cools down.
7. Use the particle theory of matter to explain why heat is required to boil water.

Practise Your Skills

8. As shown in the photo below, particles of iodine form an amber solution in one liquid and a purple solution in another liquid. When combined with other substances, do iodine particles change or does the arrangement of iodine particles change? Use the particle theory of matter to explain your answer.

For more questions, go to ScienceSource.

C12 *Thinking about Science and Technology*

Using Models

We use models to help us explain things that we cannot see. For example, the particle theory of matter is a model that helps us to understand the structure of matter.

Work with a partner to identify and describe a model that you have seen or used to describe something. An example is the way textbooks show how planets orbit the Sun.

Carbon Dioxide: Dry Ice and Greenhouse Gas

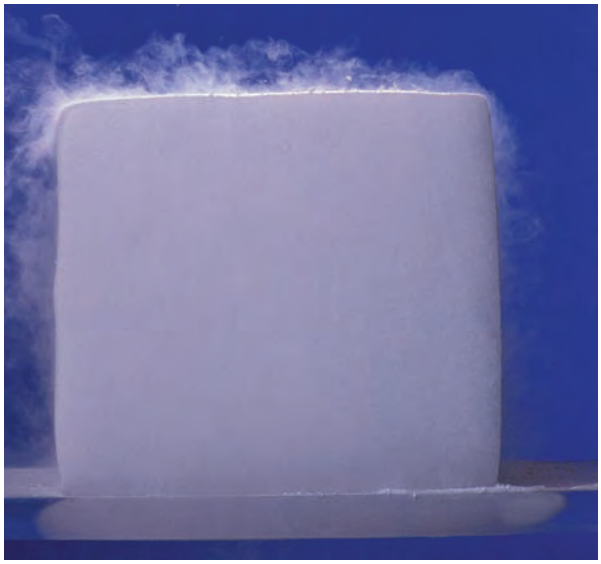


Figure 7.19 Carbon dioxide is a pure substance that sublimes. This means it changes state from solid to gas without becoming a liquid in between. That's why it is called "dry ice."

Carbon dioxide is mentioned in the news all the time because its increasing concentration in the atmosphere is thought to be one of the main causes of climate change. Carbon dioxide is one of the by-products of the combustion, or burning, of different types of natural resource fuels, such as coal, oil, and natural gas. However, we should take a closer look at this pure substance because it has some interesting chemical properties.

Sources

As mentioned, carbon dioxide is one of the products of the burning of different types of organic substances, such as wood, paper, and sugar. Along with water, carbon dioxide is also a by-product of the respiration that occurs in all plants and animals. Every time you breathe, you exhale carbon dioxide. Additionally, plants take in carbon dioxide and release oxygen and water as part of the process of photosynthesis.

Common Uses

The most common industrial use of carbon dioxide is as a refrigerant. At temperatures below –78°C, carbon dioxide becomes solid, and solid carbon dioxide is commonly known as dry ice (Figure 7.19). At ordinary temperature and air pressure, carbon dioxide changes state directly from solid to gas in a process known as sublimation. Thus, dry ice can be carried in a suitable container to keep food or other substances at temperatures below the freezing point of water.

Another common use of carbon dioxide is as a fire extinguisher. Since carbon dioxide is denser than air, it replaces the less dense air surrounding a burning material, preventing oxygen from supporting combustion.

Greenhouse Gas

In recent years, it has become known that carbon dioxide, along with other so-called greenhouse gases, has the ability to retain or trap heat from Earth's surface. This is necessary for life on Earth. However, since the middle of the 19th century (around 1860), the amount of atmospheric carbon dioxide has risen steadily. There has also been an increase in average temperature. Some environmentalists predict that, by the year 2050, the amount of carbon dioxide will have doubled from before 1900. This will lead to an increase in the average temperature on Earth (perhaps by as much as 5°C), resulting in a major and dangerous change in climate.

Questions

1. How is carbon dioxide produced naturally?
2. Why is dry ice useful?
3. Why is it important for Earth to have some carbon dioxide in its atmosphere?

7.0 Chapter Review

Assess Your Learning

Key Concept Review

1. Explain whether you would classify each of the following items as either a pure substance or a mixture. (k)

(a) apple juice

(b) fruit punch

(c) distilled water

(d) lemonade

2. A pure substance is made up of particles that are all the same, while a mixture is made of particles that are different. Use a diagram to show a mixture of distilled water, vinegar, and olive oil. (k)

3. Explain what happens to a potato chip bag as it warms in the heat of the Sun. (k)

4. Describe what happens to the particles of a solid as it changes state to become a liquid. (k)

Connect Your Understanding

5. Use the particle theory of matter to explain why cooling a gas will eventually cause it to condense into a liquid. (a)

6. If all matter is made up of particles, what is between the particles? (t)

7. Use a diagram to explain why heat is released by the particles of a liquid substance when it becomes a solid. (a)

8. In cold weather, frost forms and coats everything with a white substance. What is this substance, and why does it appear only when the weather is cold? (t)

9. What would the particles in a block of chocolate look like compared to the same amount of chocolate in liquid form? Draw particle diagrams of the block of chocolate and liquid chocolate to support your answer. (a)

After Reading — Thinking Literacy

Reflect and Evaluate

Revisit the predictions you made at the start of this chapter. What prediction did you make about the particle theory? Was your prediction confirmed or did you need to modify it as you read?

Use what you knew and what you learned to create a well-labelled diagram to represent the key points that describe the behaviour of matter. Which of the points of the particle theory of matter do you think is most important to remember? Explain why.

ACHIEVEMENT CHART CATEGORIES
(k) Knowledge and understanding (t) Thinking and investigation (c) Communication (a) Application

10. When you blow into a balloon, what makes it get bigger? Explain your answer with a particle diagram. t

11. Give an example of a mechanical mixture or solution that is made of: a

(a) two or more solids

(b) two or more liquids

(c) a solid and a liquid

Practise Your Skills

12. Prepare a T-chart with the following title: Pure Substances and Mixtures as Foods. Label the columns Pure Substances and Mixtures. Make a list of five pure substances and five mixtures that you might eat or drink every day. Some examples to help get you started include salt, pepper, olive oil, and water. t

13. When water freezes to become ice, energy must be removed. If this occurs in the freezer section of your refrigerator, where does the heat go? Explain your answer with a diagram that uses arrows to show the direction of heat flow. t

Unit Task Link

In your unit task, you will investigate water samples taken from a number of sources. Commercial and industrial processes involve isolating particles and mixing particles from different substances to form useful mixtures. During these processes, particles may escape into water supplies as waste. Using the particle theory of matter, track the source of the waste particles that may contaminate water. Think about how the waste particles interact with the water particles.

C13 Thinking about Science and Technology

Polluted Air

Air is a mixture of several gases, as well as other substances such as dust, animal fur, pollen grains, and even birds! Many human activities, such as driving cars, add substances to the air that are not good for us. Air that contains substances that are harmful is said to be polluted. Such substances may be harmful to young and old alike. Asthma is a respiratory condition, common in children, that used to be very rare. People with asthma can be strongly affected by air pollution.

What to Do

1. Identify something that you do or have done that was affected by air pollution or poor quality air, either outdoors or indoors.

Consider This

2. What steps could have been taken, if any, to prevent air from being polluted in the first place?

3. How might an understanding of particle theory help you to understand why air quality in cities can get worse in hot weather when there is no wind?

4. Share your thoughts with a classmate or the whole class.