UNIT

3

Fluids and Dynamics

Pure oxygen in liquid form

Key Ideas

7 **Kinetic molecular theory explains the characteristics of solids, liquids, and gases.**

7.1 States of Matter
7.2 Fluids and Density

8 **Fluids are affected by forces, pressure, and heat.**

8.1 Forces
8.2 Pressure
8.3 Viscosity, Adhesion, and Cohesion

9 **There are both natural and constructed fluid systems.**

9.1 Fluids Under Pressure
9.2 Constructed Fluid Systems
9.3 Natural Fluid Systems

Getting Started

The launch of space shuttle *Discovery*, July 26, 2005

Huge glowing clouds of steam and smoke flow upward as the space shuttle *Discovery* lifts off into a clear, blue sky. The huge, orange, external fuel tank holds a massive amount of liquid rocket fuel including over 1.9 million litres of liquid oxygen and liquid hydrogen. When combined in the right proportions, hydrogen and oxygen are highly explosive, which makes them an excellent rocket fuel.

Hydrogen and oxygen cannot be taken into space in their gaseous form because they would take up too much space. Compressing the gases involves placing pressure on them and squeezing them into a small space. The oxygen and hydrogen are compressed to such an extent they become liquid. This compressing process actually creates heat. The heat is removed with special devices called heat exchangers. The resulting liquid oxygen (–183°C) and hydrogen (–253°C) are extremely cold, so the external tank must be insulated.

Hydrogen	Oxygen
• At room temperature and pressure, hydrogen is a gas. • Hydrogen is highly flammable and burns with an invisible flame.	• At room temperature and pressure, oxygen is a gas. • Pure oxygen is nonflammable, but it can make other substances much more likely to burn.

If NASA did not insulate the external fuel tank, two problems would occur. First, the liquid fuels could warm up enough to change into gas. This would increase the pressure inside the tank, causing it to explode. Second, a tank without insulation would be so cold that water in the atmosphere would freeze onto the side of the tank immediately. This effect would be similar to the frost you have seen build up on windows in winter. If ice formed on the external fuel tank, pieces of ice could fall off during launch and damage the shuttle.

We would not be able to travel into space without understanding how fluids behave. The better we understand the characteristics of fluids, the better we can predict their behaviour and make use of their forces.

Word Connect

Dynamics is a branch of science that studies how materials move under the action of forces.

internet connect

Did you know that the space shuttle toilet does not flush with water? The toilet flushes with air. Find out how the space shuttle "air toilet" functions. Start your search at **www.bcscience8.ca.**

Can You Lift the Can?

Find Out ACTIVITY

In this activity, you can use your understanding of changes of state to try to lift an empty soup can without touching it.

Materials

- crushed ice or small ice cubes
- 100 mL beaker
- empty soup can
- water
- salt
- teaspoon

What to Do

1. Place an empty soup can upside down on your desk. Put 5 mL (1 tsp) of water on the soup can (in the middle).
2. Put the beaker on top of the can and the water. Make sure the beaker sits flat against the soup can. Fill the beaker about one third full with ice.
3. Add two heaping teaspoonfuls of salt to the beaker. Stir the salt-ice mixture gently. Make sure you do not move the beaker while stirring. Observe the sides of the beaker carefully while stirring.
4. Stop stirring after 3 min. Gently grab the top of the beaker, and lift.
5. Clean up and put away the equipment you have used.

What Did You Find Out?

1. How did the sides of the beaker change during your stirring?
2. How did you think the temperature of the ice-water mixture changed as salt was added?
3. (a) Were you successful at lifting the can?

   (b) Why or why not?
4. Draw a labelled illustration of your experiment using the terms solid, liquid, condensation, melting, and solidification.

Chapter 7

Kinetic molecular theory explains the characteristics of solids, liquids, and gases.

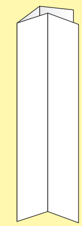
Glass is a marvellous substance. When it is cool and in solid form, it is rigid, clear, and breakable. But when it is heated to about 1000°C, glass becomes molten and flows—it becomes a fluid. When it is a fluid, artists can shape it to create beautiful works of art. This process is not as easy as it sounds—you must practise for years in order to control the heating and flow of the glass.

In this chapter, you learn how the particles in matter behave and respond when energy is added to them or removed from them.

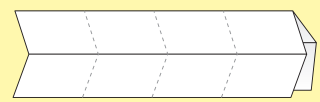
FOLDABLES™
Reading & Study Skills

Make the following Foldable to help you study the changes of state in water.

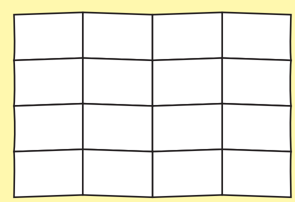
STEP 1 **Fold** a vertical sheet of paper from left to right two times. Unfold.



STEP 2 **Fold** the paper in half from top to bottom two times.



STEP 3 **Unfold** and draw lines along the folds.



STEP 4 **Label** the top row and first columns as shown below.

	Define States	+ Heat	– Heat
Liquid Water			
Water as a Gas			
Water as a Solid (Ice)			

Read and Write

As you read the chapter, define the states of matter in the *Define States* column of your Foldable. Write what happens when heat is added to or lost from each state.

On the back of the paper, illustrate the main points of the kinetic molecular theory using the terms from the front of the paper.

What You Will Learn

In this chapter, you will
- **distinguish** among solids, liquids, and gases
- **predict** how solids, liquids, and gases change when energy is added or removed
- **describe** differences between mass, volume, and density
- **determine** the density of various substances

Why It Is Important

Understanding how particles move in different states of matter helps determine how materials can be used. Thermal expansion affects the designs of buildings, roads, bridges, and machines. Density can be used to identify substances.

Skills You Will Use

In this chapter, you will
- **model** evidence of the space between particles
- **observe** evidence of thermal contraction and expansion
- **communicate** your knowledge of fluids
- **measure** density of fluids and solids
- **predict** layering of fluids

7.1 States of Matter

According to the kinetic molecular theory, all matter is made up of very small particles that are constantly moving. The more energy the particles have, the faster they can move and the farther apart they can get. Matter expands when its temperature is raised and contracts when its temperature is lowered. If enough energy is added to or removed from matter, the matter changes from one state to another.

Key Terms

condensation
evaporation
expansion
mass
melting
solidification
sublimation
volume

Oxygen, glass, and water are all examples of matter. **Matter** is anything that has mass and volume. **Mass** is the quantity of matter that a substance or object contains; the more matter, the greater the mass. For example, a bowling ball has more mass than a basketball (Figure 7.1). Mass is usually measured in grams (g) or kilograms (kg).

Volume is the amount of space taken up by a substance or object. For example, a basketball has a greater volume than a bowling ball. The volume of a liquid is usually measured in millilitres (mL), litres (L), or cubic centimetres (cm^3).

Figure 7.1 A bowling ball has more mass but less volume than a basketball.

Recall from earlier studies that there are three familiar states (phases) of matter:

- Solid is the state of matter that has a definite shape and volume (for example, a bowling ball).
- Liquid is the state of matter that has a definite volume, but its shape is determined by its surroundings (for example, water in a beaker).
- Gas is the state of matter that has its volume and shape determined by its surroundings (for example, helium in a balloon).

Did You Know?

In the past, there has been some question as to the physical state of glass. It has been argued that glass is a very stiff liquid. Glass is now known to be a type of solid called an amorphous solid.

7-1 Modelling the Particle Model

Find Out ACTIVITY

All solids, liquids, and gases are made of very small particles that have spaces in between them. In this activity, you will model evidence of the spaces .

Safety

- Ethanol is poisonous.
- Be careful to wipe up any spills.

Materials

- funnel
- water
- two 100 mL graduated cylinders
- 250 mL graduated cylinder
- 50 mL ethanol
- marbles
- 50 mL sand
- stirring rod

Science Skills

Go to Science Skill 8 for help in using models in science.

What to Do

1. Copy the following data table.

Trial	Volumes	Predicted Total Volume (mL)	Actual Total Volume (mL)
1	50 mL water 50 mL water		
2	50 mL water 50 mL ethanol		
3	50 mL marbles 50 mL sand		
4	Trial 3 plus 50 mL water		

Trial 1 Water and Water

2. Use a funnel to carefully measure 50 mL of water into each of the two 100 mL graduated cylinders.
3. Predict the total volume you will have when you combine these two volumes.
4. Add one of the volumes of water to the other. Stir with the stirring rod. Record the total volume.

Trial 2 Water and Ethanol

5. Carefully measure 50 mL of water into one 100 mL graduated cylinder and 50 mL of ethanol in the other cylinder.
6. Predict the total volume you will have when you combine these two volumes.
7. Add one of the volumes to the other. Stir with the stirring rod. Record the total volume.

Trial 3 Marbles and Sand

8. Add marbles to the 250 mL graduated cylinder until they reach the 50 mL mark.
9. Predict what the new volume will be when you add 50 mL of sand to the marbles.
10. Add 50 mL of sand. Record the new volume. Save the mixture for Trial 4.

Trial 4 Marbles, Sand, and Water

11. Predict what the new volume will be when you add 50 mL of water to the marbles and sand.
12. Add 50 mL of water. Record the new volume.
13. Clean up and put away the equipment you have used.

What Did You Find Out?

1. If the 50 mL of water and 50 mL of water did not add up to 100 mL, explain why.
2. If the 50 mL of water and 50 mL of ethanol did not add up to 100 mL, explain why.
3. If the 50 mL of marbles and 50 mL of sand did not add up to 100 mL, explain why.
4. If the 50 mL of marbles, 50 mL of sand, and 50 mL of water did not add up to 150 mL, explain why.
5. If you had added the substances in Trial 3 to the cylinder in reverse order, would the total volume be greater or less? Explain.

> **Did You Know?**
>
> How small are molecules? A small drop of water has about 1 sextillion (1 followed by 21 zeroes!) water molecules.

The Particle Model of Matter

Why can certain materials slip and slide past other materials? The answer can be explained by looking at tiny particles of matter. In further studies, you will learn about atoms and molecules. These atoms and molecules are the tiny particles of which matter is made (see Figure 7.2).

In earlier studies, you may have learned about the particle model of matter:

1. All matter is made up of very small particles. The particles are much too small to observe with the naked eye or with a light microscope.
2. There are spaces between the particles. The amount of space between the particles is different for different states of matter. For example, gases have much more space between particles than solids do.
3. The particles that make up matter are always moving.
4. The particles are attracted to one another. The strength of the attraction depends on the type of particle.

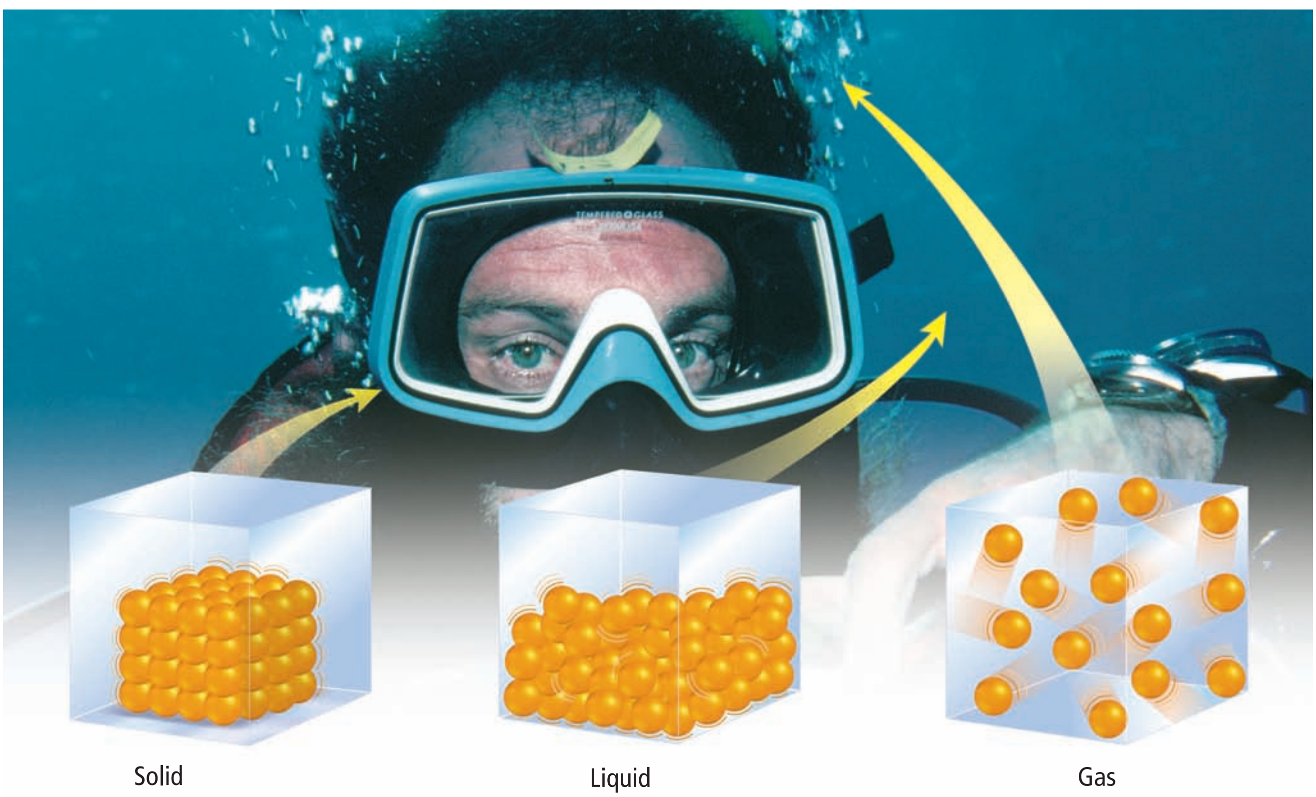


Figure 7.2A The particles in a solid are packed together tightly. This means that solids will hold a definite shape. Even though a solid does not appear to move, the particles are constantly vibrating in place.

Figure 7.2B The particles in a liquid are in contact with each other, but they can slip and slide past one another, changing their position. This slipping and sliding means liquids take the shape of their container.

Figure 7.2C Gas particles have very large spaces between them. In fact, gases are mostly empty space. Gases are quite different from liquids and solids because the particles in a gas can move freely in all directions. This is why gases always spread out or diffuse in their container.

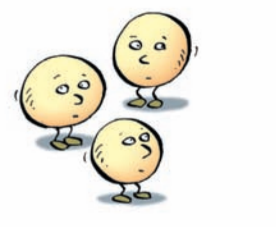
The Kinetic Molecular Theory

Kinetic energy is the energy of motion. All particles in every solid, liquid, and gas are always moving, so they have kinetic energy. Scientists have expanded the particle model and developed the **kinetic molecular theory** to explain what happens to matter when the kinetic energy of particles changes. A *model* in science is a way to think about and interpret natural events and objects. A *theory* provides a scientific explanation based on the results of experimentation.

The main points of the kinetic molecular theory include:

1. All matter is made up of very small particles (atoms and molecules).
2. There is empty space between particles.
3. Particles are constantly moving. The particles are colliding with each other and the walls of their container.

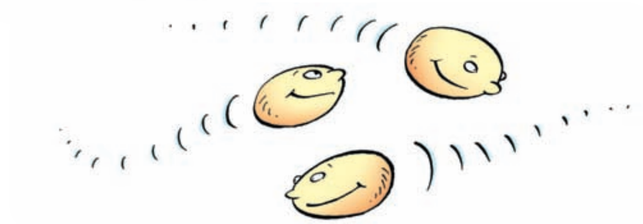
   (a) Particles of a solid are so tightly packed together they cannot move around freely. They can only vibrate.

   (b) Particles of a liquid are farther apart and they can move by sliding past each other.

   (c) Particles of a gas are very far apart and they move around quickly.

4. Energy makes particles move. The more energy the particles have, the faster they can move and the farther apart they can get.

Reading Check

1. How is a solid different from a liquid in shape and volume?
2. How are liquids and gases similar in shape and volume?
3. How are liquids and gases different in the amount of space between particles?
4. How does the behaviour of particles change as energy is added to them? How does the behaviour change as energy is lost?
5. How does the space between particles change as energy is added to them? How does the space change as energy is lost?

Suggested Activity

Find Out Activity 7-2 on page 254

Thermal Expansion and Contraction

Word Connect

The word "kinetic" comes from a Greek word meaning motion or movement. The same Greek word is the basis of the word "cinema" (moving pictures).

When you add energy to a material, you increase the kinetic energy of the particles. A common way to add energy is to add heat. What happens inside a solid, liquid, or gas as its temperature goes up? As the temperature of a solid, liquid, or gas increases, its particles move around faster. Each particle moves over a larger region, which results in more space between particles. The material that is made up of the particles *expands*. In other words, it increases in volume. In general, any kind of matter expands when its temperature increases. This effect is called **thermal expansion**.

What do you think happens to matter when its temperature decreases? The movement of the particles slows down, which means the particles take up less space as they lose energy. The matter *contracts*, or in other words, decreases in volume. This effect is called **thermal contraction**.

Different materials expand or contract with changing temperature at their own particular rate. An aluminum rod, for example, expands about three times more than a glass rod for the same change in temperature.

You might have observed that a hot drinking glass shatters when it is placed in cold water. Why do you think this happens? When it touches the cold water, the glass begins to contract. However, glass does not conduct heat well, so parts of the glass that are not yet in contact with the water remain expanded. The uneven contraction can cause enough stress to break the glass. Laboratory glassware is made of a special glass that expands much less with temperature changes than ordinary glass. The smaller amount of thermal expansion makes laboratory glassware less likely to break when heated or cooled rapidly.

Figure 7.3 shows several uses of thermal expansion and contraction.

Figure 7.3A A thermometer indicates temperature through the expansion and contraction of a liquid. Because of the narrow tube, the liquid has to expand only slightly to show a large change on the temperature scale.

Figure 7.3B As the coolant in a car becomes hotter, it expands. The plastic container shown above provides extra space for the hot coolant to seep into. When the engine is cool, the coolant contracts and no longer overflows into the container.

Figure 7.3C Highways and bridges must be built with gaps to allow the expansion of the pavement.

The Difference Between Heat and Temperature

If you consider all the kinetic energy of all the particles of a substance, the total amount of energy will be the **thermal energy** of the substance. If two substances with different thermal energies come into contact, energy will always flow from high to low thermal energy (see Figure 7.4). **Heat** is the energy transferred from one material or object to another as a result of a difference in temperature or a change in state.

As an example, think about what happens when you touch a warm cup of tea. The cup has higher thermal energy than you; when you touch it, you can feel the heat transfer from the cup to your hands. If you hold a thermometer bulb as your hands warm up, you would see the temperature increase as the total kinetic energy of the particles that make up your hands increases. When you take a **temperature** reading from a substance, you are "sampling" the average kinetic energy of its particles. Figure 7.4 shows the transfer of energy between two objects with different temperatures.

internet connect

An artisan heats metal so that it is easier to shape into jewellery. To learn more about artisan work with metal, visit **www.bcscience8.ca.**

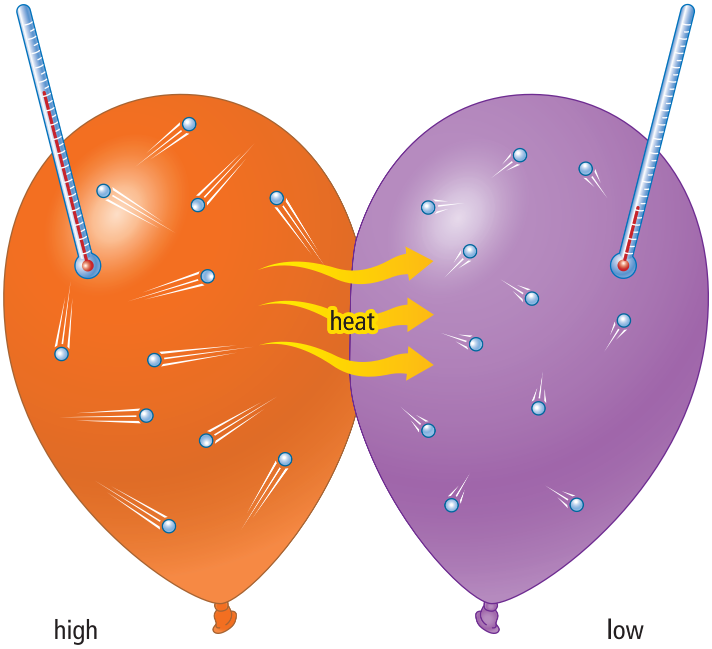


Figure 7.4 Energy is transferred between two objects with different temperatures.

Reading Check

1. What is the difference between a model and a theory?
2. What happens to matter when its temperature increases?
3. What happens to matter when its temperature decreases?
4. What is the difference between heat and temperature?

Suggested Activity

Conduct an Investigation 7-3 on page 255

Changes of State

Word Connect

You can find condensation at work in your school library. The word "condense" can describe writing something in fewer words. A condensed version of a book may have only half the amount of words as the original book.

What happens to matter if its temperature continues to rise or fall? As the space changes between the particles, so does the state of matter.

When the temperature of a solid is raised, the particles become more energetic, and they move farther and farther apart. If enough energy is added, the solid melts. **Melting** is the change of state of a substance from a solid form to a liquid form. If enough energy is added to the liquid, it evaporates. **Evaporation** is the change of state of a substance from liquid form to gas form.

When the temperature of a gas is lowered, the gas condenses. **Condensation** is the change of state of a substance from gas form to liquid form (see Figure 7.5A). If enough energy is removed from the liquid, it solidifies. **Solidification** is the change of state of a substance from liquid form to solid form.

Sublimation is the change of state of a substance directly from a solid form to a gas form. The opposite of sublimation is **deposition**. An example of deposition is when frost forms on windows on very cold days. See Figure 7.5B for an example of sublimation.

All substances have different specific temperatures at which they change state. The **melting point** is the temperature at which a solid turns to liquid (see Figure 7.6 on the next page). The **boiling point** is the temperature at which a liquid turns to gas.

Figure 7.5B Dry ice is often used in special effects to make fog. Dry ice is solid carbon dioxide, which sublimes from a solid to a gas. Dry ice is much colder than regular ice, so it condenses the moisture in the surrounding air into small water droplets we see as fog.

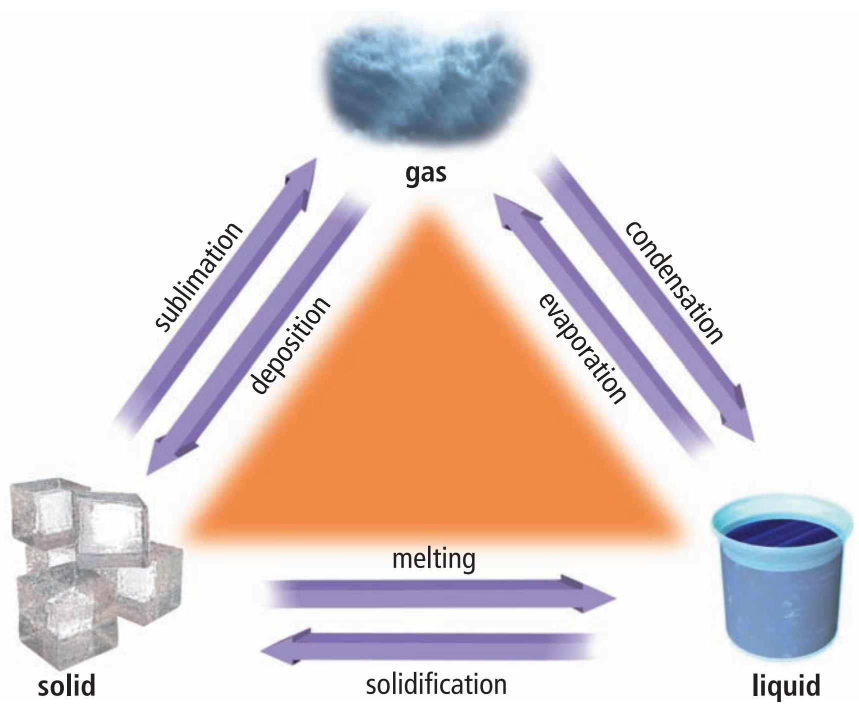
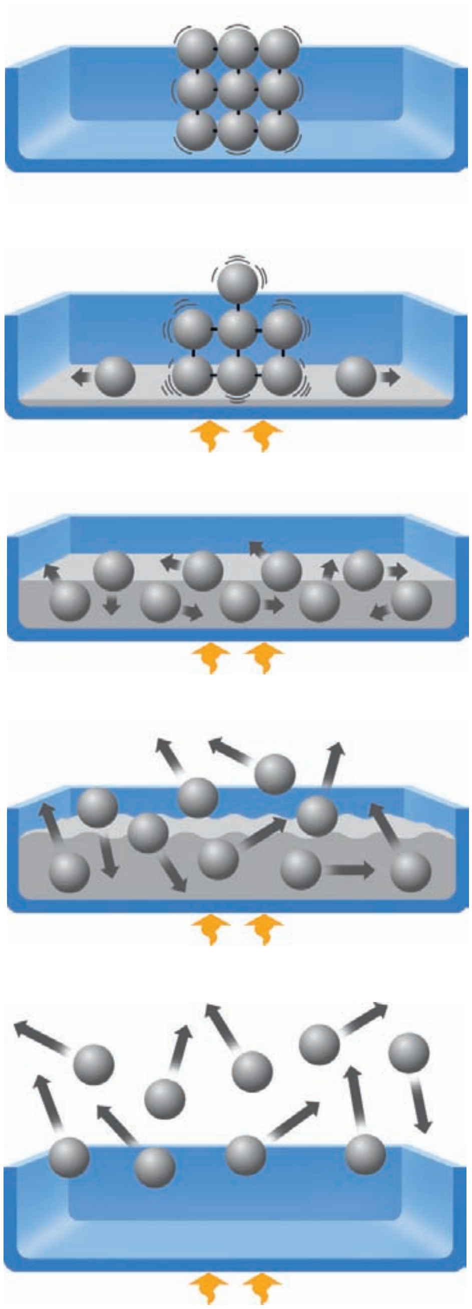


Figure 7.5A Changes of state

Changes of State in Lead



1. **Solid lead**
   Particles are very close to one another, fixed in position, and vibrate.

2. **Melting lead**
   Particles vibrate more, collide with each other, and make more space between them.

3. **Liquid lead**
   All particles are still close, but now have enough space to slide past one another.

4. **Boiling lead**
   Highly energetic particles bounce vigorously against each other, creating more space. Some particles gain enough energy to break completely free of the liquid lead.

5. **Gaseous lead.**
   All particles are highly energetic and move freely to spread out in their container. Further heating gives particles even more kinetic energy, making the gas spread out faster and farther.

Figure 7.6 Energy added to lead (shown by orange arrows) causes a change of state.

Reading Check

1. How does matter change from one state to another?
2. What is the relationship between the amount of space between particles and the state of the matter?
3. What is the difference between evaporation and sublimation?
4. How is melting similar to solidification? How is it different?

Suggested Activity

Find Out Activity 7-4 on page 256

7-2 Cool Contraction

Find Out ACTIVITY

Teacher Demonstration

In this activity, you can observe evidence that a gas contracts when it cools.

Safety

- Be careful when handling hot water.
- Be sure that the flask does not have any chips or cracks.

Materials

- flask
- small balloon
- large bowl
- ice
- protective mitt
- cold water
- very hot water

What to Do

1. Fill the bowl halfway with ice. Put cold water into the bowl to create an ice water bath.
2. Fill the flask with hot water and let it sit for 3 min.
3. Use the protective mitt to pour the hot water out of the flask. Immediately stretch the balloon over the mouth of the flask. **Caution:** the mouth of the flask may be hot.
4. Place the flask into the ice water bath. Hold the flask upright and make sure the balloon is free to move. You may have to hold the tip of the balloon if it is folded over the edge of the flask.
5. Be patient. It may take up to 10 min for the flask to cool. During this time, watch the balloon carefully.
6. Clean up and put away the equipment you have used.

What Did You Find Out?

1. What do you think happened to the temperature of the gas (air) inside the flask during this experiment?
2. How would you describe the kinetic energy of the particles of the gas inside the flask during the experiment?
3. How is the behaviour of the balloon related to the kinetic energy of the particles of gas inside the flask?
4. (a) How could you inflate the balloon?
   (b) Explain your idea by referring to the kinetic molecular theory.

7-3 Warming Down, Cooling Up

Conduct an INVESTIGATION

Inquiry Focus

Skill Check

- Observing
- Predicting
- Measuring
- Communicating

Do not touch the hot wire.

Safety

- Be careful when working with an open flame and hot objects.

Materials

- 1 m thin (20–22) gauge copper wire (without insulation)
- small hooked mass (200 g or 500 g)
- metre stick
- 2 lab stands
- 2 C clamps
- pipette or medicine dropper
- lighter
- long candles
- ice water
- aluminum foil

In this investigation, you can measure the expansion and contraction of a wire as it is heated and cooled.

Question

What evidence can you observe of solid materials expanding as they are warmed, and contracting as they are cooled?

Hypothesis

Complete the following hypothesis statements:

(a) When a material is heated, it will…

(b) When a material is cooled, it will…

Procedure

1. Read the procedure steps below. Use your hypothesis to make a prediction. What will happen to the small mass as the wire warms and cools?
2. Prepare a data table to record readings at 30 s intervals for 10 min. Give your table a title.
3. Clamp two supports firmly to the table 50–70 cm apart, and stretch the wire tightly between them. Wrap aluminum foil around the bottom of the candles to catch any drips.
4. Place the small mass in the middle of the wire. Put the metre stick behind the mass, and record the height of the mass.
5. Light the candles. Use the lighted candles to warm the entire length of the wire for several minutes. Observe and carefully record the height of the mass after each 30 s of heating for 5 min. Blow out the candles.
6. Use the pipette or medicine dropper to place 5 drops of ice water along the entire length of the wire. Carefully record the height of the mass after each 30 s of cooling for 5 min.
7. Clean up and put away the equipment you have used.

Analyze

1. Describe what happened to the copper wire as it was heated and cooled.
2. Compare your data with that of another group. What could be the reasons for any differences in data?

Conclude and Apply

1. Draw close-up diagrams that show how the wire changed during this investigation. Your diagrams should be labelled and should show what happened to the particles in the wire.

7-4 Changes of State in Water

Find Out ACTIVITY

What happens to the temperature of water as it changes state? In this activity, you can find out.

Safety

- Be careful using the hot plate.

Materials

- hot plate
- 250 mL beaker
- ice water
- stirring rod
- thermometer or temperature sensor
- thermometer clamp
- lab stand
- stopwatch

Science Skills

Go to Science Skill 7 for help with measuring temperature. Go to Science Skill 5 for help with drawing a graph.

What to Do

Part 1 Record Temperature

1. Form two hypotheses about what you think will happen:
   (a) While solid ice changes to liquid water, the temperature will (drop/stay the same/increase) because…
   (b) While liquid water boils into gas, the temperature will (drop/stay the same/increase), because…
2. Create a data table that will allow you to record the temperature every 1 min for 30 min.
3. Turn the heat on the hot plate to maximum.
4. Put about 100 mL of ice water into the beaker. Place the beaker on the hot plate. Lower the clamped thermometer into the water, but make sure it does not touch the bottom of the beaker. Begin timing.
5. Begin to gently stir the mixture of ice water. Every 1 min, record the temperature from the thermometer. Continue stirring and taking readings until 5 min after the water begins boiling.
6. Unplug the hot plate. Let the beaker and hot plate cool before putting them away.

Part 2 Create a Line Graph

7. Create a line graph of temperature versus time with the data you collected.
8. Label the area on the line graph where the ice was melting (include all parts of the line graph where ice was present).
9. Label the area on the line graph where the water was boiling.
10. Label the points on the line graph representing the times where the ice completely disappeared and where the water started to boil.

What Did You Find Out?

1. (a) Describe how the temperature changed during the time the ice melted.
   (b) Describe how the temperature changed during the time the water boiled.
2. What happened to the energy from the hot plate during melting and boiling?
3. From your observations, write a clear answer to the question at the beginning of this investigation.
4. Do your observations support your hypotheses? Explain.

Science Watch

Permafrost

Did you know that permanently frozen soil underlies about half the landmass of Canada? Permafrost is ground that remains at a temperature below freezing all year long. Living with permafrost beneath you presents some unique challenges, but offers some opportunities as well.

Aboriginal communities in Canada's North use the permafrost to their advantage. For example, the Inuit practice of building community freezers in the permafrost allows the people to keep their meat from spoiling.

Game animals are not wasted in Inuit culture. Unused meat is preserved for later use.

The ice crystals that form in a community freezer are from the moisture in people's breath and the food they bring in.

Building a home on top of permafrost requires special care. Once the home is built, it can warm the ground beneath it and melt the permafrost. When this melting occurs, the permafrost transforms from a rigid solid into a flowing mixture of solid and liquid. This mixture can damage buildings as they sink into the ground.

Global warming is causing large amounts of permafrost to melt. Scientists are concerned because once permafrost melts, the organic matter in it begins to decay. Decaying matter releases gases into the atmosphere that contribute to even more global warming. People who live on permafrost are concerned since it means that houses will be damaged, roads will become impassable, and it will become very difficult to travel to hunt for food.

Global warming is making arctic ice melt, reducing the habitat for already endangered species.

A building sinking into the permafrost

Questions

1. How do you think the density of permafrost changes as it melts? Use kinetic molecular theory to explain your answer.
2. If the permafrost continues to melt, how do you think it will affect Aboriginal communities in the Arctic?
3. If you decided to build a home on permafrost, what special measures would you take to ensure the long-term safety of the structure?

Wild, Weird, Wonderful

www Science

Plasma

Boom! A lightning strike is a thrilling display of nature's power—it is also a display of a fascinating *fourth* state of matter, plasma. Plasma is an ionized gas, a "soup" of electrically charged particles. Plasma conducts electricity very well. When a stream of plasma forms between the ground and the clouds during a thunderstorm, large amounts of electrical charge move quickly, forming lightning. When lightning discharges, it can reach a temperature of over 28 000°C in a split second—that is five times hotter than the surface of the Sun! The discharge causes the surrounding air to explode, making the sound we hear as thunder.

Our Sun is mostly plasma, and everything visible to us outside our solar system is plasma. With powerful telescopes, astronomers have taken photos of concentrations of interstellar dust and plasma called nebulae.

A powerful lightning strike

Because plasmas can reach such extreme temperatures, a plasma cutter can slice through things that would normally be difficult to cut, such as thick steel.

A nebula can be a birthplace for stars. Nebulae can also be formed when stars explode.

Coloured discharges in a plasma ball

Check Your Understanding

Checking Concepts

1. In order to turn mercury from a liquid into a solid, you must lower its temperature to approximately –39°C. Draw a diagram to represent what happens to the particles of mercury as it turns from liquid to solid.
2. Silver melts at 961°C. Some wax melts at 56°C and boils at 370°C. Is it possible to boil wax in a silver bowl? Explain.
3. Using what you know about the particle model of matter, explain the differences in appearance and behaviour between liquid water and steam.
4. When hanging electrical wires in summer, workers string the wires loosely from pole to pole. Why are the wires not strung tightly?

5. When holding a tall glass of iced tea on a warm day, your hand becomes cooler, while the glass of iced tea becomes warmer. Explain what is happening to the particles in your hand and in the glass to account for the temperature changes.
6. The metal lid on a jar is stuck on very tight. Use the kinetic molecular theory to explain whether heating or cooling the lid is the best method for helping to remove it.
7. Some hockey players curve the blades of their wooden hockey sticks by heating them and then applying force. Why do hockey players not simply force the blade to bend without heating? Explain your answer in terms of kinetic molecular theory.

Understanding Key Ideas

8. Explain why water droplets form on a cold bathroom mirror when someone has a shower. Use correct terms for the state changes that occur.
9. Global warming is an important environmental concern. One particular concern is that as the temperature of the oceans increases, water levels could rise and flood coastal communities. Explain why warmer temperatures could lead to higher water levels.
10. Two drinking glasses are stuck together, one inside the other. Write a recommendation for how to remove the outer glass without breaking either glass. Include the terms "thermal contraction" and "thermal expansion" in your recommendation.

Pause and Reflect

Suppose you had a tight-fitting nut that you wanted to put onto a bolt. Would it be a good idea to heat the nut or cool it before trying to screw it onto the bolt? Draw a picture of the bolt and use dots to represent the particles to help you think through the problem.