States of Matter

The BIG Idea The particles in solids, liquids, and gases are always in motion.

	Content Standards	Learning Objectives	Resources to Assess Mastery
Section 1	UCP.1–3, 5; A.1, 2; B.1–3	**Matter** **1. Recognize** that matter is made of particles in constant motion. **2. Relate** the three states of matter to the arrangement of particles within them. ***Main Idea*** The state of matter depends on the motion of the particles and on the attractions between them.	**Entry-Level Assessment** Options to Diagnose Entry-Level Skills and Knowledge, p. 102B **Progress Monitoring** Reading Check, pp. 102, 103, 104 Section Review, p. 106 **Summative Assessment** *ExamView® Assessment Suite*
Section 2	UCP.1–3, 5; A.1, 2; B.1–3	**Changes of State** **3. Define and compare** thermal energy and temperature. **4. Relate** changes in thermal energy to changes of state. **5. Explore** energy and temperature changes on a graph. ***Main Idea*** When matter changes state, its thermal energy changes.	**Entry-Level Assessment** Options to Diagnose Entry-Level Skills and Knowledge, p. 102B **Progress Monitoring** Reading Check, pp. 108, 113 Section Review, p. 114 **Summative Assessment** *ExamView® Assessment Suite*
Section 3	UCP.1–3, 5; A.1, 2; B.1, 2; E.1, 2; F.5; G.3 See pp. 16T–17T for a Key to Standards.	**Behavior of Fluids** **6. Explain** why some things float but others sink. **7. Describe** how pressure is transmitted through fluids. ***Main Idea*** The particles in a fluid, liquid or gas, exert a force on everything they touch.	**Entry-Level Assessment** Options to Diagnose Entry-Level Skills and Knowledge, p. 102B **Progress Monitoring** Reading Check, pp. 117, 120 Section Review, p. 123 **Summative Chapter Assessment** MindJogger, Ch. 4 *ExamView® Assessment Suite* Leveled Chapter Test Test A L1 Test B L2 Test C L3 Test Practice, pp. 130–131

Suggested Pacing				
Period	**Instruction**	**Labs**	**Review & Assessment**	**Total**
Single	4 days	4 days	2 days	10 days
Block	2 blocks	2 blocks	1 block	5 blocks

LabManager
Customize any Lab

TeacherWorks Plus
All-In-One Planner and Resource Center

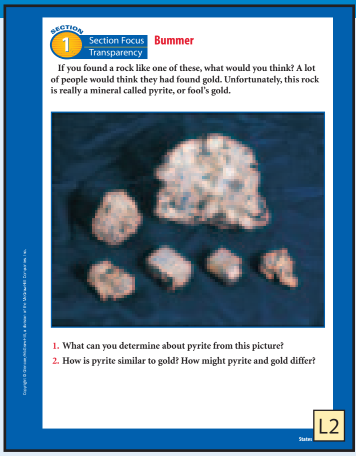
<table>
<tr><th rowspan="2">Core Instruction</th><th rowspan="2">Leveled Resources</th><th rowspan="2">Leveled Labs</th><th colspan="3">Pacing</th></tr>
<tr><th>Period</th><th></th><th>Block</th></tr>
<tr><td rowspan="2">Student Text, pp. 100–106
Section Focus Transparency, Ch. 4, Section 1
Teaching Transparency, Ch. 4, Section 1
Interactive Chalkboard, Ch. 4, Section 1
Differentiated Instruction, pp. 103, 104</td><td rowspan="2">Chapter Fast File Resources
Directed Reading for Content Mastery, p. 18 L1
Note-taking Worksheet, pp. 31, 32
Reinforcement, p. 25 L2
Enrichment, p. 28 L3
Reading Essentials, p. 53 L1 ELL
Science Notebook, p. 40 ELL</td><td rowspan="2">Launch Lab, p. 101: stearic acid, glass test tube, Celsius thermometer, watch or clock with second hand, test-tube rack or jar 15 min L2</td><td>1</td><td>Section 1, pp. 101–103 (includes Launch Lab)</td><td rowspan="2">1</td></tr>
<tr><td>2</td><td>Section 1, pp. 104–106 (includes Section Review)</td></tr>
<tr><td rowspan="3">Student Text, pp. 107–115
Section Focus Transparency, Ch. 4, Section 2
Interactive Chalkboard, Ch. 4, Section 2
Identifying Misconceptions, pp. 108, 109
Visualizing States of Matter, p. 110
Differentiated Instruction, pp. 110, 111
Applying Science, p. 111</td><td rowspan="3">Chapter Fast File Resources
Directed Reading for Content Mastery, p. 19 L1
Note-taking Worksheet, pp. 31, 32
Reinforcement, p. 26 L2
Enrichment, p. 29 L3
Reading Essentials, p. 57 L1 ELL
Science Notebook, p. 43 ELL
ActiveFolders: States of Matter L1 ELL</td><td rowspan="3">MiniLAB, p. 112: dropper, rubbing alcohol 10 min L2
*Lab, p. 115: hot plate, ice cubes, clock, stirring rod, 250-mL beaker, Celsius thermometer 30 min L1 L2 L3</td><td>3</td><td>Section 2, pp. 107–111</td><td rowspan="2">2</td></tr>
<tr><td>4</td><td>Section 2, pp. 112–114 (includes MiniLAB and Section Review)</td></tr>
<tr><td>5</td><td>Lab: The Water Cycle, p. 115</td><td rowspan="2">3</td></tr>
<tr><td rowspan="5">Student Text, pp. 116–125
Section Focus Transparency, Ch. 4, Section 3
Interactive Chalkboard, Ch. 4, Section 3
Differentiated Instruction, pp. 120, 121
Applying Math, p. 121
Chapter Study Guide, p. 127</td><td rowspan="5">Chapter Fast File Resources
Directed Reading for Content Mastery, pp. 19, 20 L1
Note-taking Worksheet, pp. 31, 32
Reinforcement, p. 27 L2
Enrichment, p. 30 L3
Reading Essentials, p. 63 L1 ELL
Science Notebook, p. 46 ELL
ActiveFolders: Principles of Gases and Liquids L1 ELL</td><td rowspan="5">MiniLAB, p. 119: plastic cup, water, index card 15 min L2
*Lab, pp.124–125: metric ruler, balance, small plastic cups (2), graduated cylinder, scissors, marbles, sink 90 min L1 L2 L3

*Lab version A L1
version B L2 L3</td><td>6</td><td>Section 3, pp. 116–119 (includes MiniLAB)</td></tr>
<tr><td>7</td><td>Section 3, pp. 120–123 (includes Section Review)</td><td rowspan="2">4</td></tr>
<tr><td>8</td><td>Lab: Design Your Own Ship, pp. 124–125</td></tr>
<tr><td>9</td><td>Lab: Design Your Own Ship, pp. 124–125</td><td rowspan="2">5</td></tr>
<tr><td>10</td><td>Study Guide, Chapter Review, and Test Practice, pp. 127–131</td></tr>
</table>

Video Lab

Transparencies

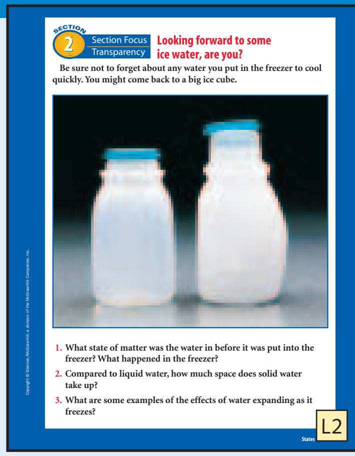
Section Focus


SECTION 1 Section Focus Transparency Bummer

If you found a rock like one of these, what would you think? A lot of people would think they had found gold. Unfortunately, this rock is really a mineral called pyrite, or fool's gold.

1. What can you determine about pyrite from this picture?
2. How is pyrite similar to gold? How might pyrite and gold differ?

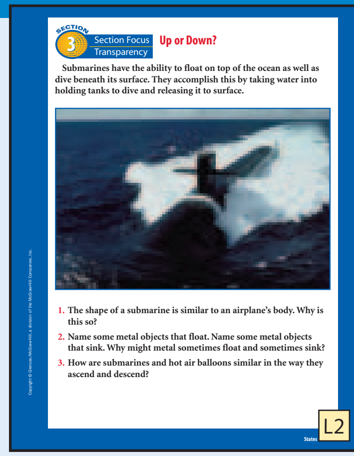
L2


SECTION 2 Section Focus Transparency Looking forward to some ice water, are you?

Be sure not to forget about any water you put in the freezer to cool quickly. You might come back to a big ice cube.

1. What state of matter was the water in before it was put into the freezer? What happened in the freezer?
2. Compared to liquid water, how much space does solid water take up?
3. What are some examples of the effects of water expanding as it freezes?

L2


SECTION 3 Section Focus Transparency Up or Down?

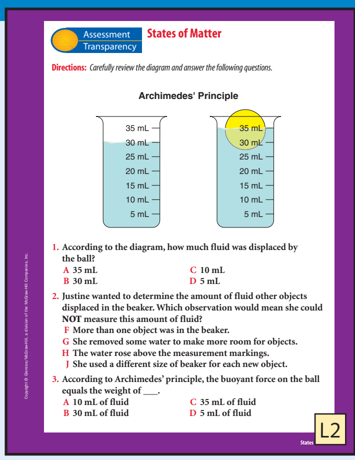
Submarines have the ability to float on top of the ocean as well as dive beneath its surface. They accomplish this by taking water into holding tanks to dive and releasing it to surface.

1. The shape of a submarine is similar to an airplane's body. Why is this so?
2. Name some metal objects that float. Name some metal objects that sink. Why might metal sometimes float and sometimes sink?
3. How are submarines and hot air balloons similar in the way they ascend and descend?

L2

This is a representation of key blackline masters available in the Teacher Classroom Resources. See Resource Manager boxes within the chapter for additional information.

Assessment

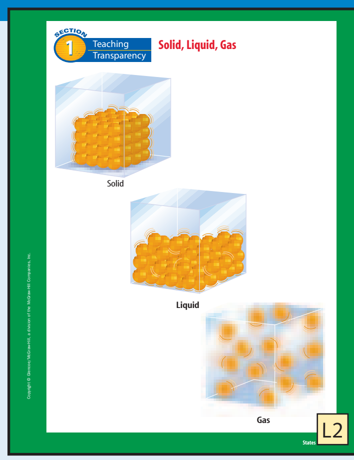

Assessment Transparency States of Matter

Directions: *Carefully review the diagram and answer the following questions.*

1. According to the diagram, how much fluid was displaced by the ball?
   A 35 mL C 10 mL
   B 30 mL D 5 mL
2. Justine wanted to determine the amount of fluid other objects displaced in the beaker. Which observation would mean she could NOT measure this amount of fluid?
   F More than one object was in the beaker.
   G She removed some water to make more room for objects.
   H The water rose above the measurement markings.
   J She used a different size of beaker for each new object.
3. According to Archimedes' principle, the buoyant force on the ball equals the weight of ___.
   A 10 mL of fluid C 35 mL of fluid
   B 30 mL of fluid D 5 mL of fluid

L2

Teaching


SECTION 1 Teaching Transparency Solid, Liquid, Gas

L2

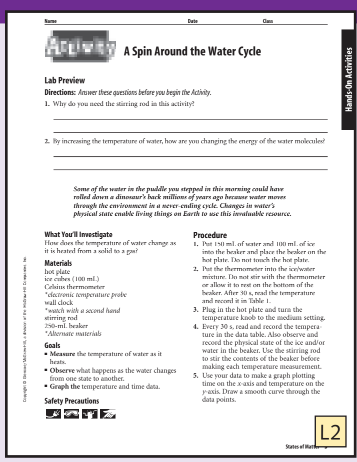
Key to Teaching Strategies

The following designations will help you decide which activities are appropriate for your students.

- L1 Level 1 activities should be appropriate for students with learning difficulties.
- L2 Level 2 activities should be within the ability range of all students.
- L3 Level 3 activities are designed for above-average students.
- ELL ELL activities should be within the ability range of English-Language Learners.
- COOP LEARN Cooperative Learning activities are designed for small group work.
- LS Multiple Learning Styles logos, as described on page 12T, are used throughout to indicate strategies that address different learning styles.
- P These strategies represent student products that can be placed into a best-work portfolio.
- PBL Problem-Based Learning activities apply real-world situations to learning.

Hands-on Activities

Student Text Lab Worksheet


Activity A Spin Around the Water Cycle

Lab Preview

Directions: *Answer these questions before you begin the Activity.*

1. Why do you need the stirring rod in this activity?
2. By increasing the temperature of water, how are you changing the energy of the water molecules?

Some of the water in the puddle you stepped in this morning could have rolled down a dinosaur's back millions of years ago because water moves through the environment in a never-ending cycle. Changes in water's physical state enable living things on Earth to use this invaluable resource.

What You'll Investigate

How does the temperature of water change as it is heated from a solid to a gas?

Materials

hot plate, ice cubes (100 mL), Celsius thermometer, *electronic temperature probe, wall clock, *watch with a second hand, stirring rod, 250-mL beaker, *Alternate materials

Goals

- Measure the temperature of water as it heats.
- Observe what happens as the water changes from one state to another.
- Graph the temperature and time data.

Safety Precautions

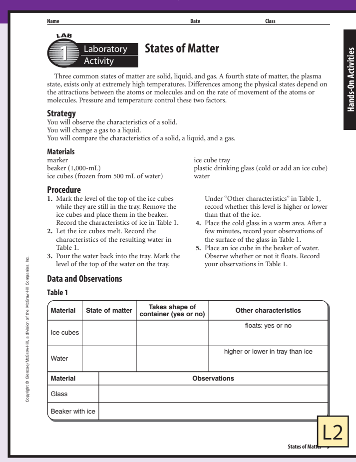
Procedure

1. Put 150 mL of water and 100 mL of ice into the beaker and place the beaker on the hot plate. Do not turn the hot plate on.
2. Put the thermometer into the ice/water mixture. Do not stir with the thermometer or allow it to rest on the bottom of the beaker. After 30 s, read the temperature and record it in Table 1.
3. Plug in the hot plate and turn the temperature knob to the medium setting.
4. Every 30 s, read and record the temperature in the data table. Also observe and record the physical state of the ice and/or water in the beaker. Use the stirring rod to stir the contents of the beaker before making each temperature measurement.
5. Use your data to make a graph plotting time on the x-axis and temperature on the y-axis. Draw a smooth curve through the data points.

Hands-On Activities

L2

Laboratory Activities


LAB 1 Laboratory Activity States of Matter

Three common states of matter are solid, liquid, and gas. A fourth state of matter, the plasma state, exists only at extremely high temperatures. Differences among the physical states depend on the attractions between the atoms or molecules and on the rate of movement of the atoms or molecules. Pressure and temperature control these two factors.

Strategy

You will observe the characteristics of a solid.
You will change a gas to a liquid.
You will compare the characteristics of a solid, a liquid, and a gas.

Materials

marker, beaker (1,000-mL), ice cubes (frozen from 500 mL of water), ice cube tray, plastic drinking glass (cold or add an ice cube), water

Procedure

1. Mark the level of the top of the ice cubes while they are still in the tray. Remove the ice cubes and place them in the beaker. Record the characteristics of ice in Table 1.
2. Let the ice cubes melt. Record the characteristics of the resulting water in Table 1.
3. Pour the water back into the tray. Mark the level of the top of the water on the tray.
4. Place the cold glass in a warm area. After a few minutes, record your observations of the surface of the glass in Table 1.
5. Place an ice cube in the beaker of water. Observe whether or not it floats. Record your observations in Table 1.

Under "Other characteristics" in Table 1, record whether this level is higher or lower than that of the ice.

Data and Observations

Table 1

Material	State of matter	Takes shape of container (yes or no)	Other characteristics
Ice cubes			floats: yes or no
Water			higher or lower in tray than ice

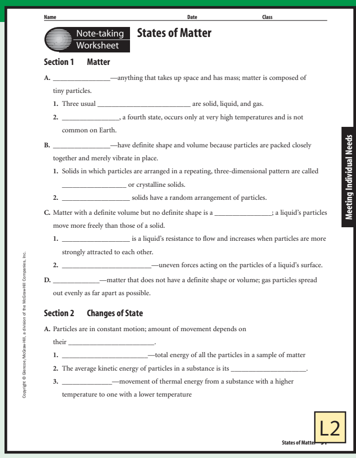
Material	Observations
Glass	
Beaker with ice	

Hands-On Activities

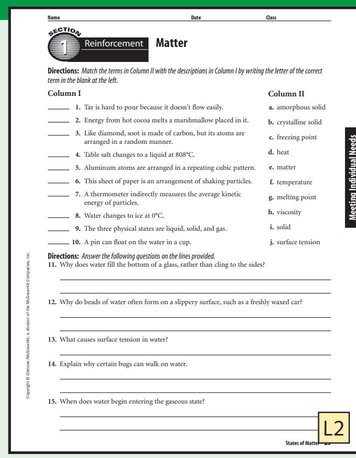
L2

Meeting Different Ability Levels

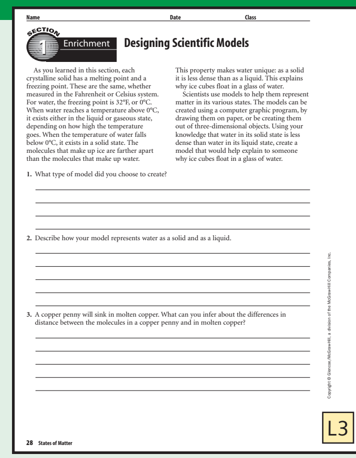
Content Outline



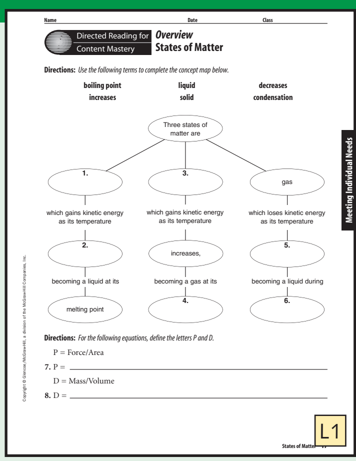
Reinforcement



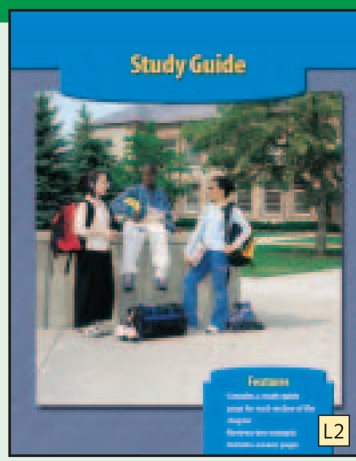
Enrichment



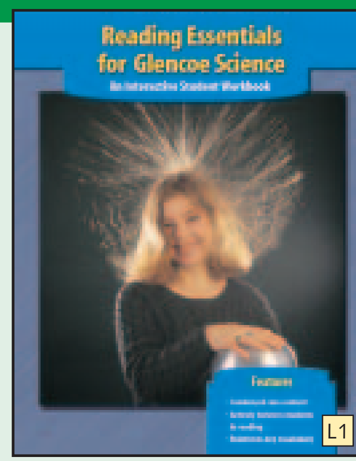
Directed Reading (English/Spanish)



Study Guide

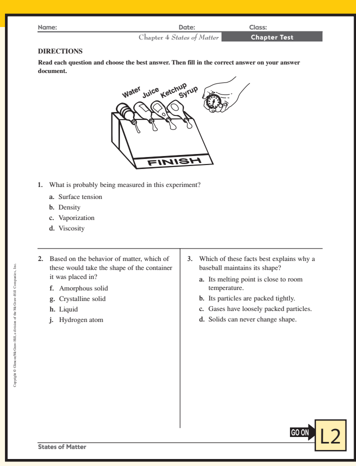


Reading Essentials

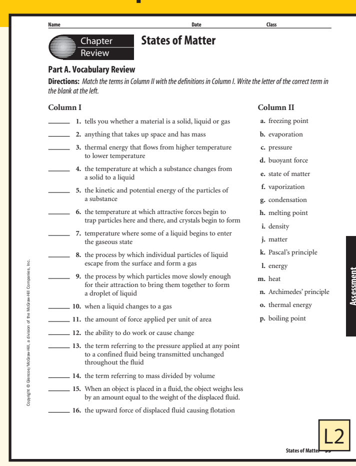


Assessment

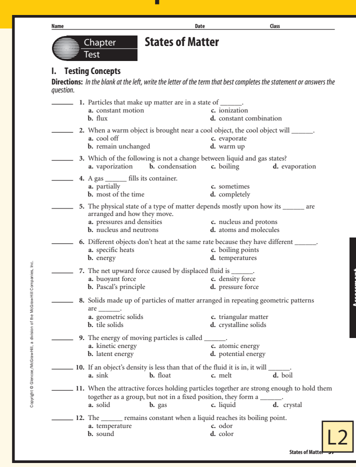
Test Practice Workbook



Chapter Review



Chapter Tests



Science Content Background

section 1 Matter

Understanding Matter

Matter is made of tiny moving particles separated by space. The three states of matter that people mainly encounter are gases, liquids, and solids. In gases, the separation of the particles is the greatest because these particles are moving the fastest. Decreasing the spaces between gas molecules by decreasing the temperature or increasing the pressure can turn gases into liquids and liquids into solids.

section 2 Changes of State

Forces Between Molecules

When a liquid is poured into a container such as a glass test tube, the liquid's surface is called the meniscus. The shape of the meniscus depends on the relative strength of the cohesive forces between liquid particles and the adhesive forces between particles of the liquid and the container. If the adhesive forces are greater, the meniscus is concave. Water in a glass tube has a concave meniscus. If the cohesive forces are greater, the meniscus is convex. Mercury in a glass tube has a convex meniscus.

Temperature

The Kelvin temperature scale is an absolute scale. It begins at absolute zero, or 0 K. Each degree on the Kelvin scale is the same magnitude as a degree on the Celsius temperature scale. The freezing point of water on the Celsius scale is 0°C; the freezing point of water on the Kelvin scale is 273 K. The average kinetic energy of the particles that make up a substance is directly proportional to its Kelvin temperature. Although particles should not be moving at absolute zero, they have a small amount of motion called the zero point energy.

Heat

Heat is energy transferred from matter at a higher temperature to matter at a lower temperature. Objects do not contain heat; they contain internal energy, which is the sum of the kinetic and potential energies of their particles. Heat can be transferred three ways: radiation is the emission of electromagnetic waves, conduction is the transfer of heat by direct contact, and convection is heat transfer by warmer matter flowing into regions of colder matter.

section 3 Behavior of Fluids

Atmospheric Pressure

Air pressure decreases rapidly with altitude. At the top of Mount Everest, 8.85 km above sea level, the pressure is only 33% of atmospheric pressure at sea level. This difference in pressure demonstrates how effectively gravity contains Earth's atmosphere.

chapter content resources

Internet Resources

For additional content background, visit **ips.msscience.com** to:

- access your book online
- find references to related articles in popular science magazines
- access Web links with related content background
- access current events with science journal topics

Print Resources

Chemistry; The Molecular Nature of Matter and Change, Martin S. Silberberg, McGraw-Hill, 2003

Chemistry, Steve S. Zumdahl, Susan A. Zumdahl, Houghton Mifflin Company, 2003

Chemistry, Raymond Chang, McGraw-Hill College, 2001

IDENTIFYING Misconceptions

Find Out What Students Think

Students may think that . . .

Matter does not include liquids or gases.

Forms of energy such as heat and light are matter.

Since solids are easy to see and feel, students usually understand easily that these materials are matter. Most gases are not directly observed, either through vision or other senses, so students may have difficulty categorizing gases as matter. Some students, however, may have too inclusive a view of matter. They fail to realize that energy may affect particles but is not composed of particles. These misunderstandings about matter can interfere with acquisition of new concepts.

Discussion

Ask students to divide a page in their Science Journals into two columns, one headed *Matter* and the other headed *Not Matter*. Read the following terms, and have students write each one in the appropriate column: *oxygen gas*, *orange juice*, *science book*, *pencil*, *electricity*, *carbon dioxide gas*, *water*, *heat*, *and light*. L2


Superstock

Promote Understanding

Demonstration

Explain that matter is composed of molecules.

- Hold up an ice cube, and establish that it is matter and is made of H_2O molecules.
- Allow the ice cube to melt. Point to the water. Is this matter? Establish that it is matter and that it is still made of H_2O molecules.
- Boil the water on a hot plate to produce steam. Is the steam matter? Establish that it is and that it is still made of H_2O molecules. Matter includes solids, liquids, and gases.
- Move your hand over the hot plate, and say that it feels warm. Is heat matter? Let students discuss this.
- Does heat have particles? Make sure students realize that heat affects particles but is not composed of particles. Heat is a form of energy, just as light and X rays are forms of energy. Energy is not matter.

Have students go back to their charts and move any terms that are not in the proper columns. L2

Assess

After completing the chapter, see *Identifying Misconceptions* in the Study Guide at the end of the chapter.

chapter 4

About the Photo

Heat Transfer The photo may help the students think about "the why" of every day events, such as putting ice cubes in a liquid or taking aluminum foil from a hot oven. While we observe the properties of matter daily, the students may have many misconceptions about the properties and characteristics that define matter.

Science Journal The students may have questions about the source of the water, why the water is warm, why the snow hasn't melted, and how they would feel in the spring.

The BIG Idea

Systems and Interactions The structure and motion of particles of matter can be analyzed to explain many properties of systems containing huge numbers of particles. Powerful changes can be caused when energy is absorbed or released by these systems. Earth's weather offers many examples of changes involving the absorption or release of energy.

Introduce the Chapter Ask students if they have ever watched a lottery drawing where they used a clear container with air forced into the container to mix the lottery balls. **Ask:** Can someone describe the motion of the lottery balls? The lottery balls randomly fly throughout the container, striking the walls of the container and striking other balls. Tell students that the motion of the lottery balls is similar to the motion of gas particles. Tell students that all particles, including the particles in a solid, have some motion.

chapter 4

States of Matter

The BIG Idea

The particles in solids, liquids, and gases are always in motion.

SECTION 1
Matter
Main Idea The state of matter depends on the motion of the particles and on the attractions between them.

SECTION 2
Changes of State
Main Idea When matter changes state, its thermal energy changes.

SECTION 3
Behavior of Fluids
Main Idea The particles in a fluid, a liquid, or a gas exert a force on everything they touch.

Ahhh!

A long, hot soak on a snowy day! This Asian monkey called a macaque is experiencing the effects of heat—the transfer of thermal energy from a warmer object to a colder object. In this chapter, you will learn about heat and the three common states of matter on Earth.

Science Journal Write why you think there is snow on the ground but the water is not frozen.

INTERACTIVE CHALKBOARD
PowerPoint® Presentations

Interactive Chalkboard

This CD-ROM is an editable Microsoft® PowerPoint® presentation that includes:

- an editable presentation for every chapter
- additional chapter questions
- animated graphics
- image bank
- links to ips.msscience.com

Start-Up Activities

Launch LAB

Experiment with a Freezing Liquid

Have you ever thought about how and why you might be able to ice-skate on a pond in the winter but swim in the same pond in the summer? Many substances change form as temperature changes.

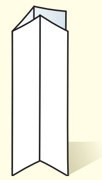
1. Make a table to record temperature and appearance. Obtain a test tube containing an unknown liquid from your teacher. Place the test tube in a rack.
2. Insert a thermometer into the liquid. **WARNING:** *Do not allow the thermometer to touch the bottom of the test tube.* Starting immediately, observe and record the substance's temperature and appearance every 30 s.
3. Continue making measurements and observations until you're told to stop.
4. **Think Critically** In your Science Journal, describe your investigation and observations. Did anything unusual happen while you were observing? If so, what?

Science Online — Preview this chapter's content and activities at ips.msscience.com

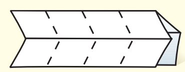
FOLDABLES™ Study Organizer

Changing States of Matter Make the following Foldable to help you study the changes in water.

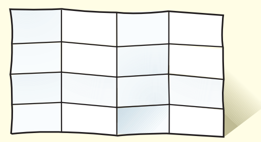
STEP 1 **Fold** a vertical sheet of paper from left to right two times. Unfold.



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 column 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 as listed on your Foldable in the *Define States* column. Write what happens when heat is added to or lost from the three states of matter.

101

Launch LAB

Purpose Use the Launch Lab to help students discover that temperature remains constant as a substance freezes. L2 COOP LEARN LS **Kinesthetic**

Preparation When students arrive, have test tubes half-filled with molten stearic acid sitting in a hot water bath in a hood at a temperature of approximately 75°C. Keep test tubes in hood until needed.

Materials laboratory-grade stearic acid, glass test tube, Celsius thermometer, watch or clock with a second hand, test-tube rack or jar

Teaching Strategy Suggest that student groups divide the responsibilities of tracking time, taking temperature readings, and recording data. Students then can graph and analyze the data individually.

Safety Precautions

- Caution students to be careful with the thermometer and wear safety glasses while working with the liquid.
- Do NOT let students remove thermometers from solid stearic acid. Breaking can occur. At the end of lab, have students return all materials to you. Reheat test tubes to remove thermometers.

Think Critically

The liquid's temperature fell gradually, remained the same as the liquid formed a white solid, then fell again. Heat was given off by the freezing liquid.

Sample Data

Time(s)	Temperature (°C)
0	74.0
30	72.5
60	70.0
90	69.5
120	69.5
150	69.5
180	69.5
210	69.0
240	68.5

Additional Chapter Media

- What's Science Got To Do With It?: *Under Pressure*
- BrainPOP *Matter Changing State; States of Matter*
- Virtual Lab: *How does thermal energy affect the state of a substance?*
- Video Lab: *Design Your Own Ship*

Monitor

One way students can better understand text is to monitor their comprehension. Monitoring entails questioning whether the text makes sense and, if not, adjusting one's reading so the text is better comprehended.

1 Learn It!

Show students how to monitor and adjust their reading by reading aloud a passage. Use the following strategies:

1. Have students raise a hand when they do not understand something you read aloud in the chapter.
2. Pause when you see a hand go up. Have the student ask his or her question. Reread the sentence and ask if the question is answered.
3. If the student says no, ask other questions to clarify the problem.

2 Practice It!

Have students read the passage on p. 102. Tell them to create a chart to list unfamiliar words from the passage and questions they have about the content. Have them write definitions and answers next to the unfamiliar words and questions.

Get Ready to Read

Monitor

1 Learn It! An important strategy to help you improve your reading is monitoring, or finding your reading strengths and weaknesses. As you read, monitor yourself to make sure the text makes sense. Discover different monitoring techniques you can use at different times, depending on the type of test and situation.

2 Practice It! The paragraph below appears in Section 1. Read the passage and answer the questions that follow. Discuss your answers with other students to see how they monitor their reading.

> All matter is made up of tiny particles, such as atoms, molecules, or ions. Each particle attracts other particles. In other words, each particle pulls other particles toward itself. These particles also are constantly moving. The motion of the particles and the strength of attraction between the particles determine a material's state of matter.
>
> — *from page 102*

- What questions do you still have after reading?
- Do you understand all of the words in the passage?
- Did you have to stop reading often? Is the reading level appropriate for you?

3 Apply It! Identify one paragraph that is difficult to understand. Discuss it with a partner to improve your understanding.

102 A CHAPTER 4 States of Matter

3 Apply It!

Ask students to choose a passage from the chapter and use the following steps to monitor their understanding: Stop and reread; identify what you do not understand; read slowly and pay attention to punctuation; look at text graphics; read for content clues; read the passage aloud; ask for help.

Target Your Reading

Use this to focus on the main ideas as you read the chapter.

Reading Tip

Monitor your reading by slowing down or speeding up depending on your understanding of the text.

1. **Before you read** the chapter, respond to the statements below on your worksheet or on a numbered sheet of paper.
   - Write an **A** if you **agree** with the statement.
   - Write a **D** if you **disagree** with the statement.

2. **After you read** the chapter, look back to this page to see if you've changed your mind about any of the statements.
   - If any of your answers changed, explain why.
   - Change any false statements into true statements.
   - Use your revised statements as a study guide.

Before You Read A or D		Statement	After You Read A or D
	1	Particles in solids vibrate in place.	
	2	A water spider can walk on water because of uneven forces acting on the surface water molecules.	
	3	Particles in a gas are far apart with empty space between them.	
	4	A large glass of warm water has the same amount of thermal energy as a smaller glass of water at the same temperature.	
	5	Boiling and evaporation are two types of vaporization.	
	6	While a substance is boiling, its temperature increases.	
	7	Pressure is, in part, related to the area over which a force is distributed.	
	8	At sea level, the air exerts a pressure of about 101,000 N per square meter.	
	9	An object will float in a fluid that is denser than itself.	

Science Online
Print out a worksheet of this page at ips.msscience.com

Target Your Reading

This anticipation guide can be used with individual students or small groups. Student responses will show existing knowledge.

For a copy of this worksheet go to ips.msscience.com.

Statements	Covered in Section
1–3	1
4–6	2
7–9	3

Answers

1. A
2. A
3. A
4. D Thermal energy is dependent on both size and temperature. A larger quantity of a substance will have more thermal energy than a smaller quantity at the same temperature.
5. A
6. D During phase changes, thermal energy changes but temperature stays the same.
7. A
8. A
9. A

Options to Diagnose Entry-Level Skills and Knowledge

Use any of these options to determine entry-level knowledge and to guide instruction:

Target Your Reading

Use the exercise on this page to determine students' existing knowledge.

ExamView® Assessment Suite

Use *ExamView® Assessment Suite* to build a pretest that covers the standards for this chapter.

section 1

Matter

as you read

What You'll Learn

- **Recognize** that matter is made of particles in constant motion.
- **Relate** the three states of matter to the arrangement of particles within them.

Why It's Important

Everything you can see, taste, and touch is matter.

Review Vocabulary

atom: a small particle that makes up most types of matter

New Vocabulary

- matter
- solid
- liquid
- viscosity
- surface tension
- gas

What is matter?

Take a look at the beautiful scene in **Figure 1.** What do you see? Perhaps you notice the water and ice. Maybe you are struck by the Sun in the background. All of these images show examples of matter. **Matter** is anything that takes up space and has mass. Matter doesn't have to be visible—even air is matter.

States of Matter All matter is made up of tiny particles, such as atoms, molecules, or ions. Each particle attracts other particles. In other words, each particle pulls other particles toward itself. These particles also are constantly moving. The motion of the particles and the strength of attraction between the particles determine a material's state of matter.

Reading Check *What determines a material's state of matter?*

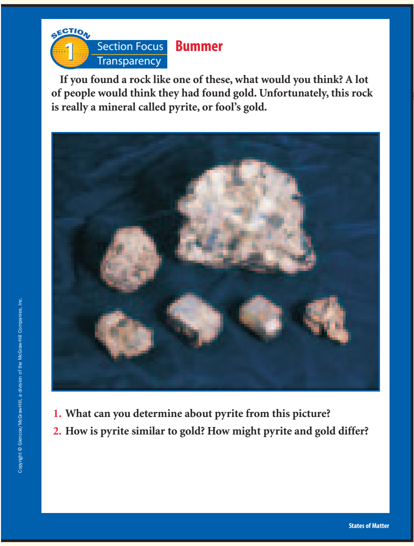
There are three familiar states of matter—solid, liquid, and gas. A fourth state of matter known as plasma occurs at extremely high temperatures. Plasma is found in stars, lightning, and neon lights. Although plasma is common in the universe, it is not common on Earth. For that reason, this chapter will focus only on the three states of matter that are common on Earth.

Figure 1 Matter exists in all four states in this scene.
Identify *the solid, liquid, gas, and plasma in this photograph.*

1 Motivate

Bellringer

Section Focus Transparencies also are available on the Interactive Chalkboard CD-ROM. L2 ELL


SECTION 1 Section Focus Transparency **Bummer**

If you found a rock like one of these, what would you think? A lot of people would think they had found gold. Unfortunately, this rock is really a mineral called pyrite, or fool's gold.

1. What can you determine about pyrite from this picture?
2. How is pyrite similar to gold? How might pyrite and gold differ?

States of Matter

Tie to Prior Knowledge

Melting Ice Ask what happens to ice that is left out of a freezer. It melts. Explain that when ice melts, its state of matter changes.

Caption Answer

Figure 1 solid ice; liquid water; gaseous air; plasma in the Sun

Reading Check

Answer the amount of motion the particles have and the strength of attraction between them

Section 1 Resource Manager

Chapter FAST FILE Resources

Transparency Activity, pp. 42, 45–46
Directed Reading for Content Mastery, pp. 17, 18
Note-taking Worksheets, pp. 31–33
Enrichment, p. 28
Reinforcement, p. 25
Lab Activity, pp. 9–10

102 CHAPTER 4 States of Matter

Solids

What makes a substance a solid? Think about some familiar solids. Chairs, floors, rocks, and ice cubes are a few examples of matter in the solid state. What properties do all solids share? A **solid** is matter with a definite shape and volume. For example, when you pick up a rock from the ground and place it in a bucket, it doesn't change shape or size. A solid does not take the shape of a container in which it is placed. This is because the particles of a solid are packed closely together, as shown in **Figure 2.**

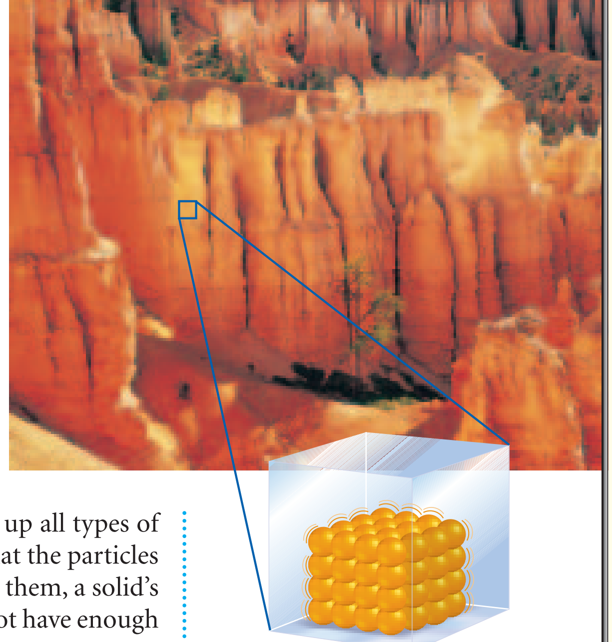


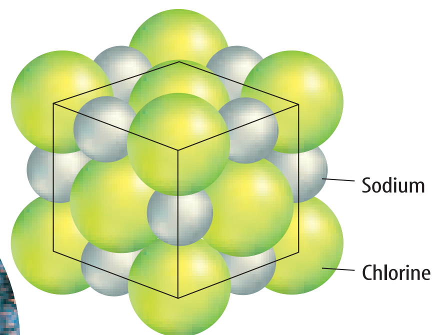
Figure 2 The particles in a solid vibrate in place while maintaining a constant shape and volume.

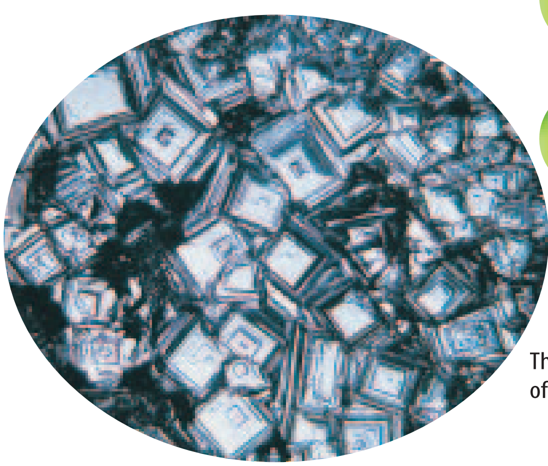
Particles in Motion The particles that make up all types of matter are in constant motion. Does this mean that the particles in a solid are moving too? Although you can't see them, a solid's particles are vibrating in place. The particles do not have enough energy to move out of their fixed positions.

Reading Check *What motion do solid particles have?*

Crystalline Solids In some solids, the particles are arranged in a repeating, three-dimensional pattern called a crystal. These solids are called crystalline solids. In **Figure 3** you can see the arrangement of particles in a crystal of sodium chloride, which is table salt. The particles in the crystal are arranged in the shape of a cube. Diamond, another crystalline solid, is made entirely of carbon atoms that form crystals that look more like pyramids. Sugar, sand, and snow are other crystalline solids.

Figure 3 The particles in a crystal of sodium chloride (NaCl) are arranged in an orderly pattern.





This magnified image shows the cubic shape of sodium chloride crystals.

2 Teach

Teacher FYI

Atom Arrangement The arrangement of atoms and molecules in a solid determines its properties. For example, diamond and graphite are two forms of carbon in which the atoms are arranged differently. In diamonds, each carbon atom is bonded to four others to form a tetrahedron. Because this structure is extremely strong, the diamond is very hard. In graphite, the carbon atoms form layers of hexagonal rings that are held together by weak forces. Because these bonds are easily broken, the graphite layers can be made to slide easily past one another. Such inherent slipperiness makes graphite an excellent lubricant.

Reading Check

Answer a vibratory motion

Make a Model

Crystal Lattice Have groups of students use **Figure 3** as a reference to make models of the sodium chloride crystal lattice. Provide colored marshmallows of different sizes and toothpicks. Discuss the features of the shape formed. L2 ELL COOP LEARN
LS **Visual-Spatial**

Differentiated Instruction

Visually Impaired Think of creative ways to provide these students with an audio recording of the chapter text. For example, ask the speech, drama, or communications teacher if their students can provide this service to you as a means of practicing their oral skills. A resource teacher or aide also may be able to assist you. L2 LS **Auditory-Musical**

Challenge Three types of crystal structures are simple cubic, body-centered cubic, and face-centered cubic. Have students research each these three structures. Ask them to describe each type, draw a picture of each, and give an example of each. L3

SECTION 1 Matter 103

Use an Analogy

Different Solids The particles in a crystalline solid occupy defined spaces, like eggs in an egg carton. In an amorphous solid the particles are in a random arrangement, more like lemons in a bowl.

Reading Check

Answer The particles in amorphous solids have a random arrangement instead of an ordered arrangement.

INTEGRATE History

Fresh Water What waterways, if any, are near your home and school? Are the waterways still being used? Are they natural or man-made, like canals? Find out how the waterways were used by the early settlers of your town.

Activity

States of Matter Have students create a Venn diagram of the properties of water as a solid, a liquid, and a gas. The diagrams should include characteristics such as shape, volume, and particle motion. L2

INTEGRATE History

Fresh Water Early settlers have always decided to build their homes near water. The rivers provided ways for people to travel, drinking water for themselves and their animals, and irrigation for farming. Over time, small communities became larger communities with industry building along the same water.

Amorphous Solids Some solids come together without forming crystal structures. These solids often consist of large particles that are not arranged in a repeating pattern. Instead, the particles are found in a random arrangement. These solids are called amorphous (uh MOR fuhs) solids. Rubber, plastic, and glass are examples of amorphous solids.

Reading Check *How is a crystalline solid different from an amorphous solid?*

Liquids

From the orange juice you drink with breakfast to the water you use to brush your teeth at night, matter in the liquid state is familiar to you. How would you describe the characteristics of a liquid? Is it hard like a solid? Does it keep its shape? A **liquid** is matter that has a definite volume but no definite shape. When you pour a liquid from one container to another, the liquid takes the shape of the container. The volume of a liquid, however, is the same no matter what the shape of the container. If you pour 50 mL of juice from a carton into a pitcher, the pitcher will contain 50 mL of juice. If you then pour that same juice into a glass, its shape will change again but its volume will not.

Free to Move The reason that a liquid can have different shapes is because the particles in a liquid move more freely, as shown in **Figure 4,** than the particles in a solid. The particles in a liquid have enough energy to move out of their fixed positions but not enough energy to move far apart.

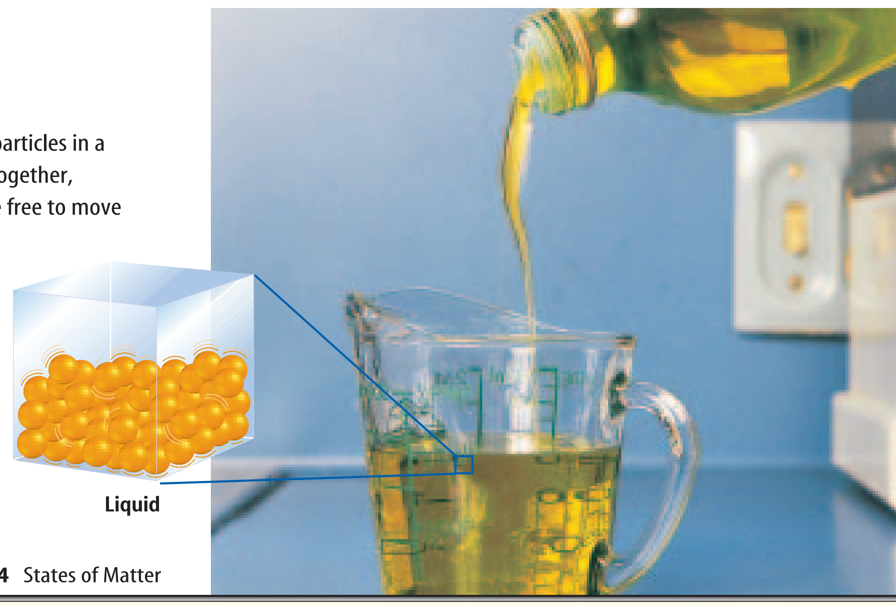


Figure 4 The particles in a liquid stay close together, although they are free to move past one another.

Differentiated Instruction

English-Language Learners Have English-Language Learners create the Venn diagram in the activity on this page in their native language. Ask them to translate the diagram into English. Then have the students share the translated version with a classmate. L2 ELL

Viscosity Do all liquids flow the way water flows? You know that honey flows more slowly than water and you've probably heard the phrase "slow as molasses." Some liquids flow more easily than others. A liquid's resistance to flow is known as the liquid's **viscosity.** Honey has a high viscosity. Water has a lower viscosity. The slower a liquid flows, the higher its viscosity is. The viscosity results from the strength of the attraction between the particles of the liquid. For many liquids, viscosity increases as the liquid becomes colder.

Surface Tension If you're careful, you can float a needle on the surface of water. This is because attractive forces cause the particles on the surface of a liquid to pull themselves together and resist being pushed apart. You can see in **Figure 5** that particles beneath the surface of a liquid are pulled in all directions. Particles at the surface of a liquid are pulled toward the center of the liquid and sideways along the surface. No liquid particles are located above to pull on them. The uneven forces acting on the particles on the surface of a liquid are called **surface tension.** Surface tension causes the liquid to act as if a thin film were stretched across its surface. As a result you can float a needle on the surface of water. For the same reason, the water spider can move around on the surface of a pond or lake. When a liquid is present in small amounts, surface tension causes the liquid to form small droplets.

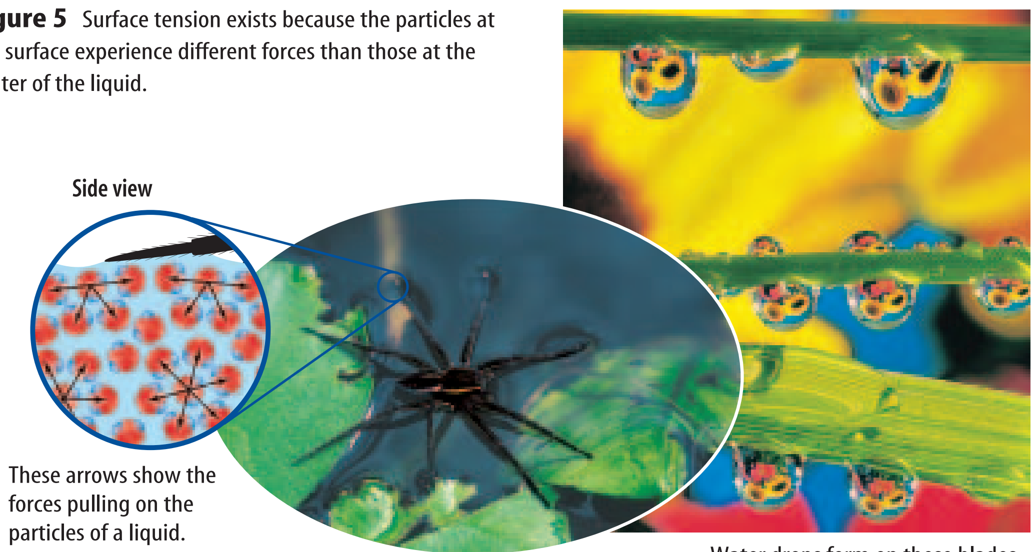
Science Online

Topic: Plasma

Visit ips.msscience.com for Web links to information about the states of matter.

Activity List four ways that plasma differs from the other three states of matter

Figure 5 Surface tension exists because the particles at the surface experience different forces than those at the center of the liquid.



These arrows show the forces pulling on the particles of a liquid.

Surface tension allows this spider to float on water as if the water had a thin film.

Water drops form on these blades of grass due to surface tension.

Visual Learning

Figure 5 Explain the forces that are in effect in each photo and ask why surface tension is not a property of solids. The particles in solids are rigidly held in place and are not free to move. L2 LS **Logical-Mathematical**

Use an Analogy

Cohesion One force of attraction that causes particles to pull toward each other is called cohesion. Cohesion between particles is similar to the force of gravity that pulls inward to produce the spherical shape of the planets and sun.

Fun Fact

The physics department of the University of Queensland, Australia, has a funnel of pitch—the black, sticky material used in blacktopping roads and waterproofing basements—that is so viscous it takes about ten years for a drop to drip.

Discussion

Plasma In conjunction with the online resources, discuss the information about plasma the students found. Plasma consists of ions, electrons, and atomic nuclei that have lost all their electrons. It forms at temperatures higher than 5000°C. Information about new and practical uses of plasma can be found at www.plasma.org. L2

LAB DEMONSTRATION

Purpose to show how temperature affects the viscosity of a liquid

Materials 2 jars, syrup or molasses, refrigerator, 2 small beakers, stopwatch

Preparation Add 10 mL of syrup to each jar. Place one jar in a refrigerator overnight, and allow the other to stand at room temperature.

Procedure Have one student pour all the cold syrup into one beaker while another student pours all the room-temperature syrup into the other beaker. Have remaining students record the time it takes to empty each jar.

Expected Outcome The cold syrup takes longer to pour.

Assessment

Why does the cold syrup have higher viscosity than the warmer syrup? The particles in the cold syrup are closer together and exert a stronger force upon each other than do the warmer particles.

Quick Demo

Movement of Gases

Materials can of air freshener

Estimated Time five minutes

Procedure Demonstrate that gases spread out to fill all available space by spraying a small amount of air freshener in one corner of the room. Have students raise their hands when they first smell the scent. Have students explain the movement of the particles.

3 Assess

DAILY INTERVENTION

Check for Understanding

Logical-Mathematical Have students explain why motor oil is made in a wide range of viscosities. Motor oil must remain fluid enough to protect a car engine in a wide range of weather conditions. L2

Reteach

Compression of Gases Blow up a balloon and tie it closed at the neck. Use the balloon to illustrate to students that a gas can be compressed. Ask students what happens to the gas in the balloon if you twist the balloon at the center. Some gas moves into each end of the balloon, where it is compressed into a smaller space. L1 LS **Visual-Spatial**

Assessment

Content Have students prepare cartoons that compare and contrast the properties of solids, liquids, and gases. Use **Performance Assessment in the Science Classroom**, p. 133. P

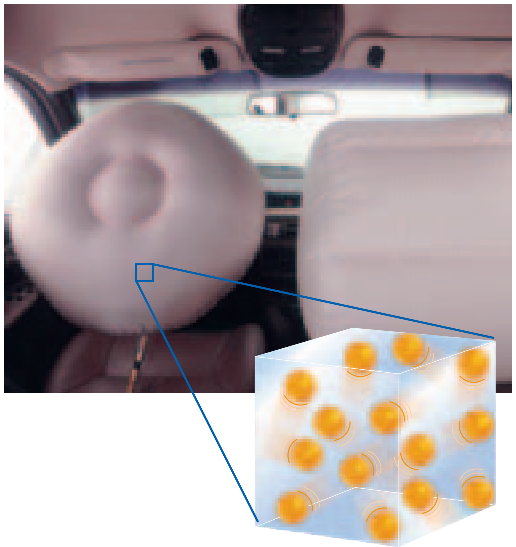


Figure 6 The particles in gas move at high speeds in all directions. The gas inside these air bags spreads out to fill the entire volume of the bag.

Gases

Unlike solids and liquids, most gases are invisible. The air you breathe is a mixture of gases. The gas in the air bags in **Figure 6** and the helium in some balloons are examples of gases. **Gas** is matter that does not have a definite shape or volume. The particles in gas are much farther apart than those in a liquid or solid. Gas particles move at high speeds in all directions. They will spread out evenly, as far apart as possible. If you poured a small volume of a liquid into a container, the liquid would stay in the bottom of the container. However, if you poured the same volume of a gas into a container, the gas would fill the container completely. A gas can expand or be compressed. Decreasing the volume of the container squeezes the gas particles closer together.

Vapor Matter that exists in the gas state but is generally a liquid or solid at room temperature is called vapor. Water, for example, is a liquid at room temperature. Thus, water vapor is the term for the gas state of water.

section 1 review

Summary

What is matter?

- Matter is anything that takes up space and has mass. Solid, liquid, and gas are the three common states of matter.

Solids

- Solids have a definite volume and shape.
- Solids with particles arranged in order are called crystalline solids. The particles in amorphous solids are not in any order.

Liquids

- Liquids have definite volume but no defined shape.
- Viscosity is a measure of how easily liquids flow.

Gases

- Gases have no definite volume or shape.
- Vapor refers to gaseous substances that are normally liquids or solids at room temperature.

Self Check

1. **Define** the two properties of matter that determine its state.
2. **Describe** the movement of particles within solids, liquids, and gases.
3. **Name** the property that liquids and solids share. What property do liquids and gases share?
4. **Infer** A scientist places 25 mL of a yellow substance into a 50-mL container. The substance quickly fills the entire container. Is it a solid, liquid, or gas?
5. **Think Critically** The particles in liquid A have a stronger attraction to each other than the particles in liquid B. If both liquids are at the same temperature, which liquid has a higher viscosity? Explain.

Applying Skills

6. **Concept Map** Draw a Venn diagram in your Science Journal and fill in the characteristics of the states of matter.

Science Online ips.msscience.com/self_check_quiz

section 1 review

1. motion of particles and strength of attraction between particles
2. solids: particles are very close together and vibrate back and forth; liquids: particles are farther apart and individual particles can flow past each other; gases: particles are very far apart and move quickly
3. solid—liquid—constant volume liquid—gas—take on shape of container
4. Gas state, the particles take the shape and volume of their container.
5. Liquid A—greater attraction among molecules, the greater the viscosity
6. Check students' work for characteristics that are shared and not shared by states of matter.

section 2

Changes of State

Thermal Energy and Heat

Shards of ice fly from the sculptor's chisel. As the crowd looks on, a swan slowly emerges from a massive block of ice. As the day wears on, however, drops of water begin to fall from the sculpture. Drip by drip, the sculpture is transformed into a puddle of liquid water. What makes matter change from one state to another? To answer this question, you need to think about the particles that make up matter.

Energy Simply stated, energy is the ability to do work or cause change. The energy of motion is called kinetic energy. Particles within matter are in constant motion. The amount of motion of these particles depends on the kinetic energy they possess. Particles with more kinetic energy move faster and farther apart. Particles with less energy move more slowly and stay closer together.

The total kinetic and potential energy of all the particles in a sample of matter is called **thermal energy.** Thermal energy, an extensive property, depends on the number of particles in a substance as well as the amount of energy each particle has. If either the number of particles or the amount of energy in each particle changes, the thermal energy of the sample changes. With identically sized samples, the warmer substance has the greater thermal energy. In **Figure 7,** the particles of hot water from the hot spring have more thermal energy than the particles of snow on the surrounding ground.

as you read

***What* You'll Learn**

- **Define and compare** thermal energy and temperature.
- **Relate** changes in thermal energy to changes of state.
- **Explore** energy and temperature changes on a graph.

***Why* It's Important**

Matter changes state as it heats up or cools down.

Review Vocabulary

energy: the ability to do work or cause change

New Vocabulary

- thermal energy
- temperature
- heat
- melting
- freezing
- vaporization
- condensation

Figure 7 These girls are enjoying the water from the hot spring. **Infer** *why the girls appear to be comfortable in the hot spring while there is snow on the ground.*

Section 2 Resource Manager

Chapter *FAST FILE* Resources

Transparency Activity, p. 43
Directed Reading for Content Mastery, p. 19
Lab Activity, pp. 11–13
Enrichment, p. 29
MiniLab, p. 3
Reinforcement, p. 26
Lab Worksheets, pp. 5–6

Reading and Writing Skill Activities, p. 17

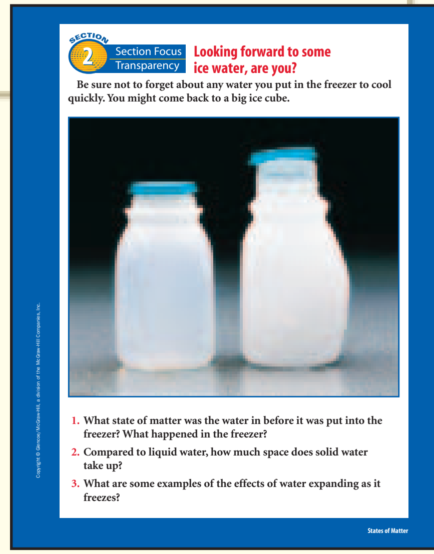
Earth Science Critical Thinking/Problem Solving, p. 10

Physical Science Critical Thinking/Problem Solving, p. 10

1 Motivate

Bellringer

Section Focus Transparencies also are available on the Interactive Chalkboard CD-ROM. L2 ELL



Tie to Prior Knowledge

Particle Arrangement Remind students of the differences in particle arrangement and movement in solids, liquids, and gases.

Caption Answer

Figure 7 The water in the hot spring has more thermal energy than the surrounding snow.

2 Teach

Caption Answer

Figure 8 the hot tea

INTEGRATE Physics

Types of Energy All types of energy can cause change. What changes can each of the forms of energy listed in the Integrate Physics cause? thermal energy—make particles move faster; chemical energy—make and break chemical bonds; electrical energy—illuminate light bulbs, turn motors; electromagnetic energy of light—stimulate cells so we can see; nuclear energy—change mass to energy. L2 LS **Logical-Mathematical**

Research Have students research geothermal energy. Topics that should be included are a definition of the term, how geothermal energy is being used for household applications and how geothermal energy is being used to generate electricity. L2

Reading Check

Answer When a substance is heated, it gains thermal energy; therefore, its particles move faster and its temperature rises.

IDENTIFYING Misconceptions

Thermal Energy Students may not realize that two systems at the same temperature can have different amounts of thermal energy. For example, a cup of boiling water and a pot of boiling water may have the same temperature, but the pot of water has more thermal energy and can transfer more heat.

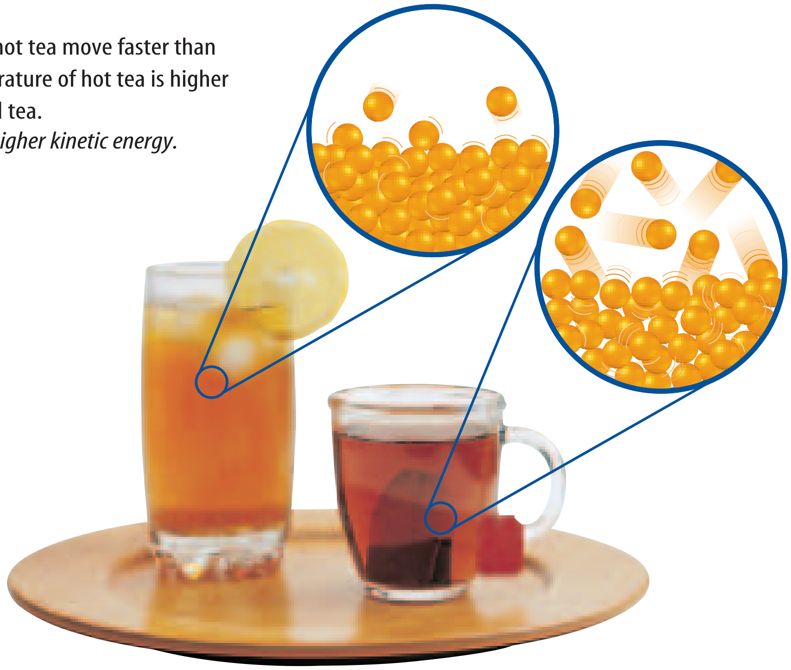


Figure 8 The particles in hot tea move faster than those in iced tea. The temperature of hot tea is higher than the temperature of iced tea.
Identify *which tea has the higher kinetic energy.*

INTEGRATE Physics

Types of Energy Thermal energy is one of several different forms of energy. Other forms include the chemical energy in chemical compounds, the electrical energy used in appliances, the electromagnetic energy of light, and the nuclear energy stored in the nucleus of an atom. Make a list of examples of energy that you are familiar with.

Temperature Not all of the particles in a sample of matter have the same amount of energy. Some have more energy than others. The average kinetic energy of the individual particles is the **temperature,** an intensive property, of the substance. You can find an average by adding up a group of numbers and dividing the total by the number of items in the group. For example, the average of the numbers 2, 4, 8, and 10 is $(2 + 4 + 8 + 10) \div 4 = 6$. Temperature is different from thermal energy because thermal energy is a total and temperature is an average.

You know that the iced tea is colder than the hot tea, as shown in **Figure 8.** Stated differently, the temperature of iced tea is lower than the temperature of hot tea. You also could say that the average kinetic energy of the particles in the iced tea is less than the average kinetic energy of the particles in the hot tea.

Heat When a warm object is brought near a cooler object, thermal energy will be transferred from the warmer object to the cooler one. The movement of thermal energy from a substance at a higher temperature to one at a lower temperature is called **heat.** When a substance is heated, it gains thermal energy. Therefore, its particles move faster and its temperature rises. When a substance is cooled, it loses thermal energy, which causes its particles to move more slowly and its temperature to drop.

Reading Check *How is heat related to temperature?*

Science Journal

Thermal Energy on the Move Ask students to pay attention to the transfer of thermal energy around them and record all the examples they observe in one 24-hour period. Have them write their observations in their Science Journals. They should include for each example where the thermal energy came from and where it went. L2 LS **Naturalist**

108 CHAPTER 4 States of Matter

Specific Heat

As you study more science, you will discover that water has many unique properties. One of those is the amount of heat required to increase the temperature of water as compared to most other substances. The specific heat of a substance is the amount of heat required to raise the temperature of 1 g of a substance 1°C.

Substances that have a low specific heat, such as most metals and the sand in **Figure 9,** heat up and cool down quickly because they require only small amounts of heat to cause their temperatures to rise. A substance with a high specific heat, such as the water in **Figure 9,** heats up and cools down slowly because a much larger quantity of heat is required to cause its temperature to rise or fall by the same amount.

Figure 9 The specific heat of water is greater than that of sand. The energy provided by the Sun raises the temperature of the sand much faster than the water.

Changes Between the Solid and Liquid States

Matter can change from one state to another when thermal energy is absorbed or released. This change is known as change of state. The graph in **Figure 11** shows the changes in temperature as thermal energy is gradually added to a container of ice.

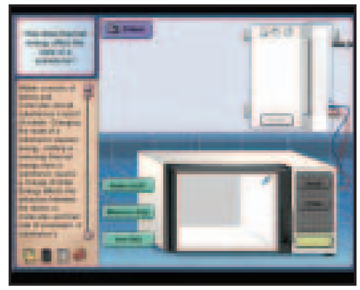
Melting As the ice in **Figure 11** is heated, it absorbs thermal energy and its temperature rises. At some point, the temperature stops rising and the ice begins to change into liquid water. The change from the solid state to the liquid state is called **melting.** The temperature at which a substance changes from a solid to a liquid is called the melting point. The melting point of water is 0°C.

Amorphous solids, such as rubber and glass, don't melt in the same way as crystalline solids. Because they don't have crystal structures to break down, these solids get softer and softer as they are heated, as you can see in **Figure 10.**

Figure 10 Rather than melting into a liquid, glass gradually softens. Glass blowers use this characteristic to shape glass into beautiful vases while it is hot.

Virtual Labs

Thermal Energy *How does thermal energy affect the state of a substance?*



Activity

Specific Heat Between 0°C and 100°C the specific heat of water is about 4.18 J/g°C. Ask students to find the specific heats of several metals and compare them with the specific heat of water. Have them make a table from their findings. The specific heat of silver between these temperatures is 0.235 J/g°C. Between 20°C and 100°C the specific heat of aluminum is 0.903 J/g°C, the specific heat of copper is 0.385 J/g°C, and the specific heat of iron is 0.449 J/g°C. These range from about one-twentieth that of water to about one-fifth that of water.

L3 LS **Logical-Mathematical** P

IDENTIFYING Misconceptions

Changing States Students may think particles of a substance can change state only at the melting point or boiling point of the substance. In fact, at any temperature different particles of a substance have different amounts of kinetic energy and may have enough energy to change state. Melting and boiling occur when the number of particles with enough energy to change state is great enough that the average kinetic energy of the particles is at the melting point or the boiling point of the substance.

Active Reading

Quickwrites This strategy will help students identify what they already know about thermal energy, temperature, and changes in state. Have students list ideas about these topics, and then share their ideas with the class. Students can then write those ideas freely in a paragraph and share them with the class during or after a learning experience on the states of matter.

L1

Curriculum Connection

Geography Earth's temperature has increased during the past few decades. Have students research how this increase could cause changes in the state of water and the effects these changes could have on a specific geographic region. For example, melting of the polar ice caps is causing erosion along coastlines.

L3 LS **Linguistic**

NATIONAL GEOGRAPHIC

Visualizing States of Matter

Have students examine the pictures and read the captions. Then ask the following questions.

During the melting and vaporization process the temperature remains constant. Look at the graph and identify which factor continues to increase. thermal energy

What changes in molecular attraction occur as water goes from a solid to a liquid to a gas? As a solid, the molecules have the most attraction for each other. As a liquid, the molecular attraction has decreased. As a gas, there is no longer any molecular attraction between the molecules.

During condensation, what must be removed from the gas in order for the gas to become a liquid? thermal energy

Activity

Water Molecule Have the students write a letter about the life of a water molecule as it goes from a solid to a gas. How free and what will it see as a molecule that's part of a solid, liquid, or vapor? L2 LS **Linguistic**

NATIONAL GEOGRAPHIC **VISUALIZING STATES OF MATTER**

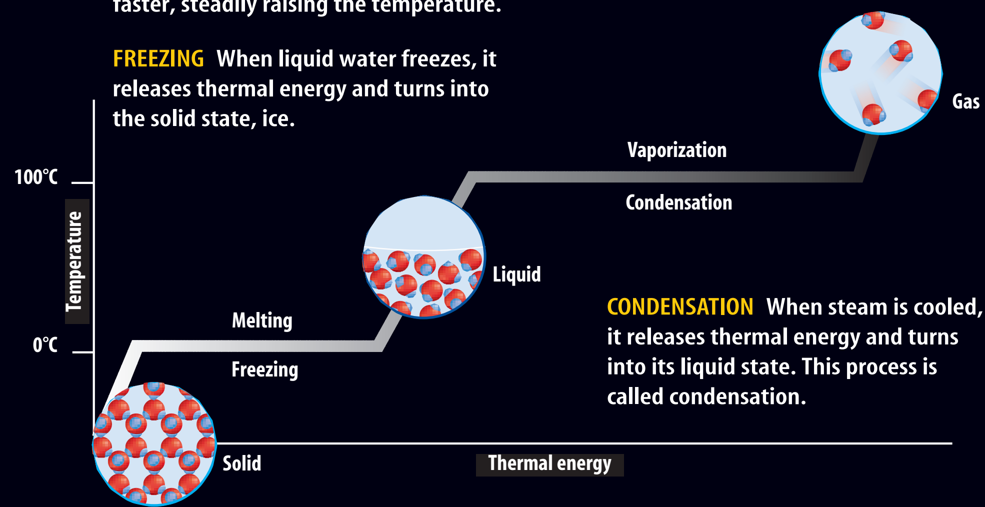
Figure 11

Like most substances, water can exist in three distinct states—solid, liquid, or gas. At certain temperatures, water changes from one state to another. This diagram shows what changes occur as water is heated or cooled.

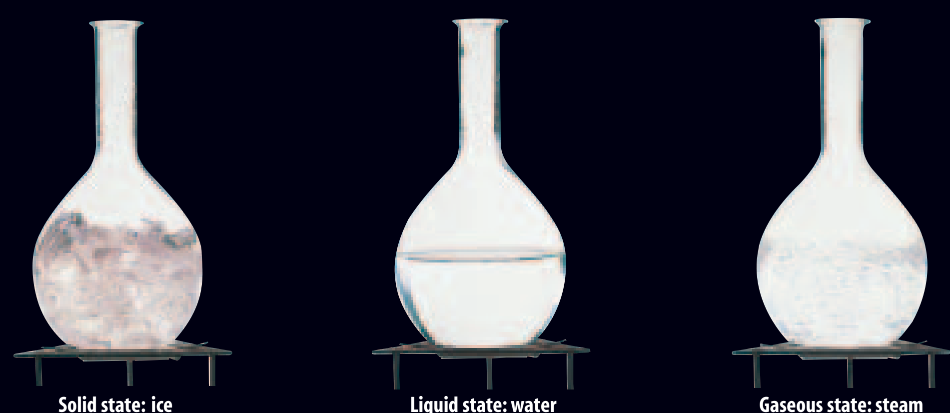
MELTING When ice melts, its temperature remains constant until all the ice turns to water. Continued heating of liquid water causes the molecules to vibrate even faster, steadily raising the temperature.

FREEZING When liquid water freezes, it releases thermal energy and turns into the solid state, ice.

VAPORIZATION When water reaches its boiling point of 100°C, water molecules are moving so fast that they break free of the attractions that hold them together in the liquid state. The result is vaporization—the liquid becomes a gas. The temperature of boiling water remains constant until all of the liquid turns to steam.



CONDENSATION When steam is cooled, it releases thermal energy and turns into its liquid state. This process is called condensation.



Differentiated Instruction

Challenge Have students find out the energy changes that occur during the refrigeration cycle. Have them also find the properties of environmentally safe refrigerants and share the information with the class. L3

Freezing The process of melting a crystalline solid can be reversed if the liquid is cooled. The change from the liquid state to the solid state is called **freezing.** As the liquid cools, it loses thermal energy. As a result, its particles slow down and come closer together. Attractive forces begin to trap particles, and the crystals of a solid begin to form. As you can see in **Figure 11,** freezing and melting are opposite processes.

The temperature at which a substance changes from the liquid state to the solid state is called the freezing point. The freezing point of the liquid state of a substance is the same temperature as the melting point of the solid state. For example, solid water melts at 0°C and liquid water freezes at 0°C.

During freezing, the temperature of a substance remains constant while the particles in the liquid form a crystalline solid. Because particles in a liquid have more energy than particles in a solid, energy is released during freezing. This energy is released into the surroundings. After all of the liquid has become a solid, the temperature begins to decrease again.

Science Online

Topic: Freezing Point Study

Visit ips.msscience.com for Web links to information about freezing.

Activity Make a list of several substances and the temperatures at which they freeze. Find out how the freezing point affects how the substance is used.

Applying Science

How can ice save oranges?

During the spring, Florida citrus farmers carefully watch the fruit when temperatures drop close to freezing. When the temperatures fall below 0°C, the liquid in the cells of oranges can freeze and expand. This causes the cells to break, making the oranges mushy and the crop useless for sale. To prevent this, farmers spray the oranges with water just before the temperature reaches 0°C. How does spraying oranges with water protect them?

Identifying the Problem

Using the diagram in **Figure 11,** consider what is happening to the water at 0°C. Two things occur. What are they?

Solving the Problem

1. What change of state and what energy changes occur when water freezes?
2. How does the formation of ice on the orange help the orange?

Fun Fact

The field of low-temperature physics is called cryogenics. Scientists working in this area have been able to reach temperatures as low as 0.0001 K.

Discussion

Energy Since temperature doesn't change as a substance is freezing, the kinetic energy of its particles doesn't change. But the substance is losing energy. What kind of energy is the substance losing? It is losing the potential energy of the attraction between the particles. L3 LS **Logical-Mathematical**

Applying Science

Teaching Strategies

Show students the difference between an orange that has been frozen below 0°C (-2.2°C) and one that has not been frozen. The layer of ice on top protects the orange from the colder air temperatures. Point out that this is also what occurs when a lake freezes over. The ice on top protects the water beneath, so fish can survive.

Answers

1. The two changes that occur are the phase change from water to ice and the loss of energy (exothermic) when the phase change occurs.
2. The ice forms at 0°C forming a coating on the orange that acts as insulation against the colder air temperature. Some of the energy that is released when the ice forms goes into the orange.

Differentiated Instruction

Learning Disabled Help students analyze the questions posed in Applying Science by breaking down the process that occurs as the water sprayed on the oranges freezes. Draw diagrams and use arrows to show the energy transfers involved and relate them to the graphs on the previous page. L2 LS **Logical-Mathematical**

Purpose Students observe that a liquid absorbs heat from its surroundings as it evaporates. L1 LS **Kinesthetic**

Materials dropper, rubbing alcohol

Teaching Strategy Prevent waste by providing students with small amounts of alcohol.

Safety Precautions Students should wear goggles when performing this MiniLAB. Alcohol is flammable. There should be no open flames in the lab.

Analysis

1. The alcohol evaporated.
2. The hand felt cool where the alcohol was located. The alcohol removed heat from the skin as it evaporated, and then the hand warmed up again.
3. Sweating alone will not cool the body. The sweat has to evaporate for the body to feel cooler.

Assessment

Content Explain how the body is cooled by perspiration. Heat from the body is absorbed as perspiration evaporates from the skin. Use **Performance Assessment in the Science Classroom,** p. 89.

Caption Answer

Figure 12 Vaporization describes a liquid changing to a gas.

Visual Learning

Figure 12 Discuss with students the difference between evaporation and boiling. Could both occur at the same time? Yes; while some particles are becoming gas inside the liquid, other liquid particles can become gas at the surface. L2 LS **Logical-Mathematical**

Observing Vaporization

Procedure

1. Use a **dropper** to place one drop of **rubbing alcohol** on the back of your hand.
2. Describe how your hand feels during the next 2 min.
3. Wash your hands.

Analysis

1. What changes in the appearance of the rubbing alcohol did you notice?
2. What sensation did you feel during the 2 min? How can you explain this sensation?
3. Infer how sweating cools the body.

Changes Between the Liquid and Gas States

After an early morning rain, you and your friends enjoy stomping through the puddles left behind. But later that afternoon when you head out to run through the puddles once more, the puddles are gone. The liquid water in the puddles changed into a gas. Matter changes between the liquid and gas states through vaporization and condensation.

Vaporization As liquid water is heated, its temperature rises until it reaches 100°C. At this point, liquid water changes into water vapor. The change from a liquid to a gas is known as **vaporization** (vay puh ruh ZAY shun). You can see in **Figure 11** that the temperature of the substance does not change during vaporization. However, the substance absorbs thermal energy. The additional energy causes the particles to move faster until they have enough energy to escape the liquid as gas particles.

Two forms of vaporization exist. Vaporization that takes place below the surface of a liquid is called boiling. When a liquid boils, bubbles form within the liquid and rise to the surface, as shown in **Figure 12.** The temperature at which a liquid boils is called the boiling point. The boiling point of water is 100°C.

Vaporization that takes place at the surface of a liquid is called evaporation. Evaporation, which occurs at temperatures below the boiling point, explains how puddles dry up. Imagine that you could watch individual water molecules in a puddle. You would notice that the molecules move at different speeds. Although the temperature of the water is constant, remember that temperature is a measure of the average kinetic energy of the molecules. Some of the fastest-moving molecules overcome the attractive forces of other molecules and escape from the surface of the water.

Figure 12 During boiling, liquid changes to gas, forming bubbles in the liquid that rise to the surface.
Define *the word that describes a liquid changing to the gas.*

Teacher FYI

Maxwell-Boltzmann Distribution At a given temperature, the motions of the particles in a substance vary according to a well-defined distribution of particle speeds called the Maxwell-Boltzmann distribution. This distribution looks similar to a bell curve but is not as symmetrical. The limit on the fastest speeds is the speed of light, while zero is the lowest speed a particle can have.

Figure 13 The drops of water on these glasses and pitcher of lemonade were formed when water vapor in the air lost enough energy to return to the liquid state. This process is called condensation.

Location of Molecules It takes more than speed for water molecules to escape the liquid state. During evaporation, these faster molecules also must be near the surface, heading in the right direction, and they must avoid hitting other water molecules as they leave. With the faster particles evaporating from the surface of a liquid, the particles that remain are the slower, cooler ones. Evaporation cools the liquid and anything near the liquid. You experience this cooling effect when perspiration evaporates from your skin.

Condensation Pour a nice, cold glass of lemonade and place it on the table for a half hour on a warm day. When you come back to take a drink, the outside of the glass will be covered by drops of water, as shown in **Figure 13.** What happened? As a gas cools, its particles slow down. When particles move slowly enough for their attractions to bring them together, droplets of liquid form. This process, which is the opposite of vaporization, is called **condensation.** As a gas condenses to a liquid, it releases the thermal energy it absorbed to become a gas. During this process, the temperature of the substance does not change. The decrease in energy changes the arrangement of particles. After the change of state is complete, the temperature continues to drop, as you saw in **Figure 11.**

Reading Check *What energy change occurs during condensation?*

Condensation formed the droplets of water on the outside of your glass of lemonade. In the same way, water vapor in the atmosphere condenses to form the liquid water droplets in clouds. When the droplets become large enough, they can fall to the ground as rain.

Science Online

Topic: Condensation
Visit ips.msscience.com for Web links to information about how condensation is involved in weather.

Activity Find out how condensation is affected by the temperature as well as the amount of water in the air.

Teacher FYI

Refrigerant Cycle Refrigerators take advantage of temperature changes caused by the condensation and evaporation of refrigerant, which is carried through a series of pipes in the refrigerator. Refrigerant absorbs heat from inside the refrigerator and vaporizes. This process cools food. The refrigerant is then piped to the back of the refrigerator where it releases its heat to the surrounding air and condenses back into a liquid. The cycle then repeats.

Reading Check

Answer During condensation, a gas releases energy as its particles become more ordered.

Visual Learning

Figure 13 Have students describe the various places that heat transfer is occurring in **Figure 13.** L2 LS **Visual-Spatial**

Quick Demo

Condensation

Materials hot plate, beaker, water, small mirror, thermal mitt

Estimated Time 10 minutes

Procedure Place a beaker half to three-quarters full of water on a hot plate. Have the water heating on a high temperature, but not boiling before the students arrive. Increase the temperature so that the water boils. While wearing the thermal mitt, hold the mirror over the boiling beaker. Hold this position until there is condensation on the mirror. Have the students explain condensation in terms of energy loss and gain.

Curriculum Connection

Geography Have students research how changes of state contribute to the formation of deserts near the Tropic of Cancer. Ask students to make posters with diagrams illustrating their findings. Warm moist air from the equator rises and flows northward and southward. As this moist air cools it loses its moisture. This dry air then descends over the Tropics of Capricorn and Cancer pulling moisture out of the ground by evaporation and drying out the land. This pattern has produced a belt of deserts along the Tropics of Capricorn and Cancer. L2 LS **Linguistic**

3 Assess

DAILY INTERVENTION

Check for Understanding

Logical-Mathematical If you have an automatic ice-cube maker in your freezer, you may have noticed that the older ice cubes at the bottom of the tray are much smaller than the newer cubes at the top. Use what you have learned to explain why. The faster molecules on the surface of an ice cube can escape from the cube and become a gas. Over time, the ice cube will completely sublimate away. L2 LS

Reteach

Evaporation and Boiling Have students explain the difference between evaporation and boiling. Boiling occurs when particles below the surface of a liquid change from liquid to gas. Evaporation occurs when particles at the surface of a liquid change from liquid to gas. L2 LS **Logical-Mathematical**

Assessment

Oral Have students hypothesize what would happen if the unknown substance from the Launch Lab were reheated. The substance would melt at the same temperature at which it froze. The temperature would remain constant while the substance was melting, then increase gradually. Use **Performance Assessment in the Science Classroom,** p. 93.

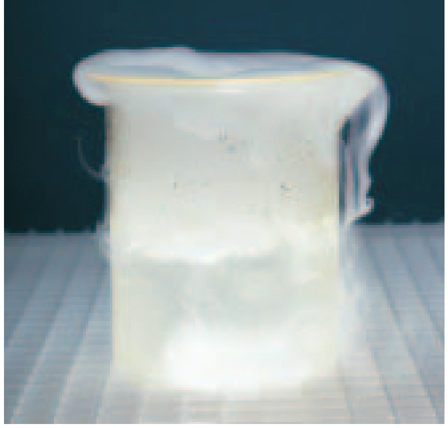


Figure 14 The solid carbon dioxide (dry ice) at the bottom of this beaker of water is changing directly into gaseous carbon dioxide. This process is called sublimation.

Changes Between the Solid and Gas States

Some substances can change from the solid state to the gas state without ever becoming a liquid. During this process, known as sublimation, the surface particles of the solid gain enough energy to become a gas. One example of a substance that undergoes sublimation is dry ice. Dry ice is the solid form of carbon dioxide. It often is used to keep materials cold and dry. At room temperature and pressure, carbon dioxide does not exist as a liquid. Therefore, as dry ice absorbs thermal energy from the objects around it, it changes directly into a gas. When dry ice becomes a gas, it absorbs thermal energy from water vapor in the air. As a result, the water vapor cools and condenses into liquid water droplets, forming the fog you see in **Figure 14.**

section 2 review

Summary

Thermal Energy and Heat

- Thermal energy depends on the amount of the substance and the kinetic energy of particles in the substance.
- Heat is the movement of thermal energy from a warmer substance to a cooler one.

Specific Heat

- Specific heat is a measure of the amount of energy required to raise 1 g of a substance 1°C.

Changes Between Solid and Liquid States

- During all changes of state, the temperature of a substance stays the same.

Changes Between Liquid and Gas States

- Vaporization is the change from the liquid state to a gaseous state.
- Condensation is the change from the gaseous state to the liquid state.

Changes Between Solid and Gas States

- Sublimation is the process of a substance going from the solid state to the gas state without ever being in the liquid state.

Self Check

1. **Describe** how thermal energy and temperature are similar. How are they different?
2. **Explain** how a change in thermal energy causes matter to change from one state to another. Give two examples.
3. **List** the three changes of state during which energy is absorbed.
4. **Describe** the two types of vaporization.
5. **Think Critically** How can the temperature of a substance remain the same even if the substance is absorbing thermal energy?
6. **Write** a paragraph in your Science Journal that explains why you can step out of the shower into a warm bathroom and begin to shiver.

Applying Math

7. **Make and Use Graphs** Use the data you collected in the Launch Lab to plot a temperature-time graph. At what temperature does the graph level off? What was the liquid doing during this time period?
8. **Use Numbers** If sample A requires 10 calories to raise the temperature of a 1-g sample 1°C, how many calories does it take to raise a 5-g sample 10°C?

Science Online ips.msscience.com/self_check_quiz

section 2 review

1. Thermal energy is the total amount of energy contained in a body whereas temperature measures the average kinetic energy of the particles in the body. Both deal with quantities of energy.
2. As thermal energy changes, the kinetic energy of the particles changes. If their kinetic energy increases, particles can overcome the attractive forces holding them together. If their kinetic energy decreases, particles can become subject to the forces pulling them together. Examples will vary.
3. melting, vaporization, and sublimation
4. Boiling occurs when particles below the surface of a liquid change from liquid to gas. Evaporation occurs when particles at the surface of a liquid change from liquid to gas.
5. The temperature remains the same because the absorbed energy is being used to break attractive forces between the particles of a substance as it changes state.
6. The water on your skin absorbs heat from your body and evaporates.
7. Check students' work. Sample data can be found in the teacher margin of the Launch Lab. Answers may vary, but should be near 69.5°C. The liquid was freezing during this time period.
8. specific heat = cal/(g × °C); 10 cal/(1 g × 1°C) = x cal/(5 g × 10°C), therefore x = 500 cal

LAB

The Water Cycle

Water is all around us and you've used water in all three of its common states. This lab will give you the opportunity to observe the three states of matter and to discover for yourself if ice really melts at 0°C and if water boils at 100°C.

Real-World Question

How does the temperature of water change as it is heated from a solid to a gas?

Goals

- **Measure** the temperature of water as it heats.
- **Observe** what happens as the water changes from one state to another.
- **Graph** the temperature and time data.

Materials

hot plate
ice cubes (100 mL)
Celsius thermometer
**electronic temperature probe*
wall clock
**watch with second hand*
stirring rod
250-mL beaker
**Alternate materials*

Safety Precautions

Procedure

1. Make a data table similar to the table shown.
2. Put 150 mL of water and 100 mL of ice into the beaker and place the beaker on the hot plate. Do not touch the hot plate.
3. Put the thermometer into the ice/water mixture. Do not stir with the thermometer or allow it to rest on the bottom of the beaker. After 30 s, read and record the temperature in your data table.

Characteristics of Water Sample

Time (min)	Temperature (°C)	Physical State
	Answers will vary.	

4. Plug in the hot plate and turn the temperature knob to the medium setting.
5. Every 30 s, read and record the temperature and physical state of the water until it begins to boil. Use the stirring rod to stir the contents of the beaker before making each temperature measurement. Stop recording. Allow the water to cool.

Analyze Your Data

Use your data to make a graph plotting time on the *x*-axis and temperature on the *y*-axis. Draw a smooth curve through the data points.

Conclude and Apply

1. **Describe** how the temperature of the ice/water mixture changed as you heated the beaker.
2. **Describe** the shape of the graph during any changes of state.

Communicating Your Data

Add labels to your graph. Use the detailed graph to explain to your class how water changes state. **For more help, refer to the Science Skill Handbook.**

BENCH TESTED

Real-World Question

Purpose Students observe the solid and liquid states of water. L1 LS **Kinesthetic**

Process Skills measure, observe, make and use tables, use numbers, make and use graphs, infer

Time 30 minutes

Procedure

Alternate Materials electronic temperature probe

Safety Precautions Caution students not to use the thermometer as a stirrer or allow it to rest on the bottom of the beaker during heating.

Teaching Strategy Crushed ice or small pieces will give quicker results.

Analyze Your Data

Expected Outcome Students' graphs should show increasing temperature until a change of state occurs and then be level until the next change of state.

Conclude and Apply

1. The temperature increased, stayed the same for a period of time, then increased again.
2. During changes of state, the graph leveled off.

Assessment

Content How would the graphs change if twice as much ice were used? The temperature would rise more slowly and the plateau would be longer. Use **Performance Assessment in the Science Classroom**, p. 101. LS **Logical-Mathematical**

Communicating Your Data

Encourage students to compare graphs with other students and discuss possible reasons for inconsistent data.

section 3

Behavior of Fluids

as you read

What You'll Learn

- **Explain** why some things float but others sink.
- **Describe** how pressure is transmitted through fluids.

Why It's Important

Pressure enables you to squeeze toothpaste from a tube, and buoyant force helps you float in water.

Review Vocabulary
force: a push or pull

New Vocabulary
- pressure
- buoyant force
- Archimedes' principle
- density
- Pascal's principle

Pressure

It's a beautiful summer day when you and your friends go outside to play volleyball, much like the kids in **Figure 15.** There's only one problem—the ball is flat. You pump air into the ball until it is firm. The firmness of the ball is the result of the motion of the air particles in the ball. As the air particles in the ball move, they collide with one another and with the inside walls of the ball. As each particle collides with the inside walls, it exerts a force, pushing the surface of the ball outward. A force is a push or a pull. The forces of all the individual particles add together to make up the pressure of the air.

Pressure is equal to the force exerted on a surface divided by the total area over which the force is exerted.

$$\text{pressure} = \frac{\text{force}}{\text{area}}$$

When force is measured in newtons (N) and area is measured in square meters (m^2), pressure is measured in newtons per square meter (N/m^2). This unit of pressure is called a pascal (Pa). A more useful unit when discussing atmospheric pressure is the kilopascal (kPa), which is 1,000 pascals.

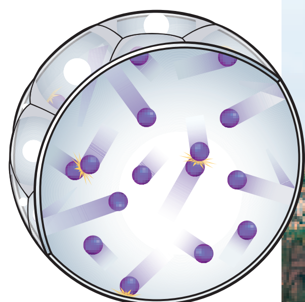


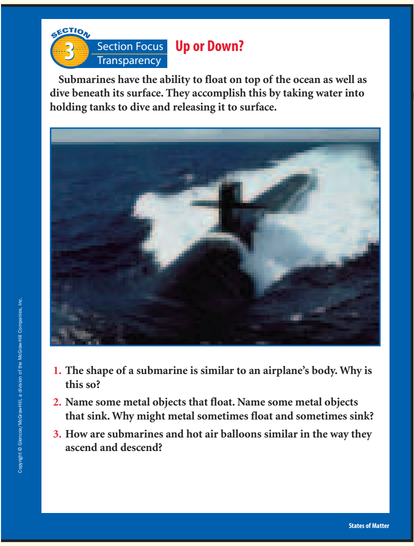
Figure 15 Without the pressure of air inside this volleyball, the ball would be flat.

1 Motivate

Bellringer

INTERACTIVE CHALKBOARD

Section Focus Transparencies also are available on the Interactive Chalkboard CD-ROM. L2 ELL


SECTION 3 Section Focus Transparency **Up or Down?**

Submarines have the ability to float on top of the ocean as well as dive beneath its surface. They accomplish this by taking water into holding tanks to dive and releasing it to surface.

1. The shape of a submarine is similar to an airplane's body. Why is this so?
2. Name some metal objects that float. Name some metal objects that sink. Why might metal sometimes float and sometimes sink?
3. How are submarines and hot air balloons similar in the way they ascend and descend?

States of Matter

Tie to Prior Knowledge

Pumping Bicycle Tires Ask students whether they have ever pumped up bicycle tires. Have a volunteer describe what happens during the process. More and more air molecules are pushed into the tire, increasing the pressure inside. Explain that in this section students will explore how the motion of particles of matter is related to different kinds of pressure occurring in fluids.

Section 3 Resource Manager

Chapter FAST FILE Resources
- Directed Reading for Content Mastery, pp. 19, 20
- Transparency Activity, p. 44
- MiniLab, p. 4
- Enrichment, p. 30
- Reinforcement, p. 27
- Lab Worksheet, pp. 7–8

Mathematics Skill Activities, p. 31

Performance Assessment in the Science Classroom, p. 39

Physical Science Critical Thinking/Problem Solving, p. 3

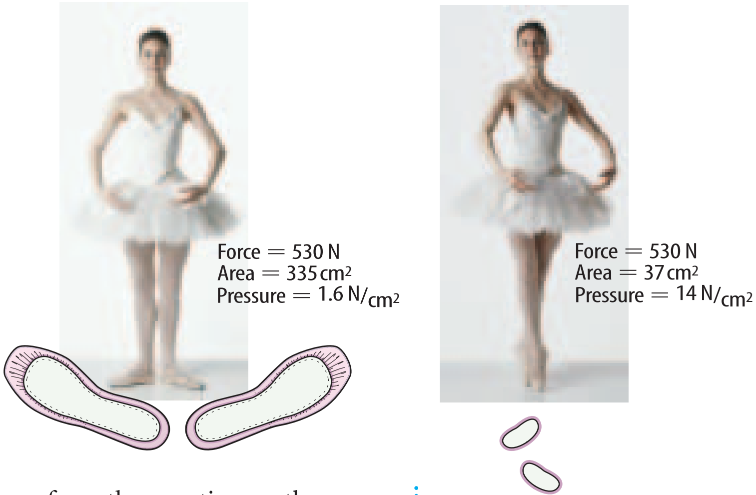


Figure 16 The force of the dancer's weight on pointed toes results in a higher pressure than the same force on flat feet.
Explain *why the pressure is higher.*

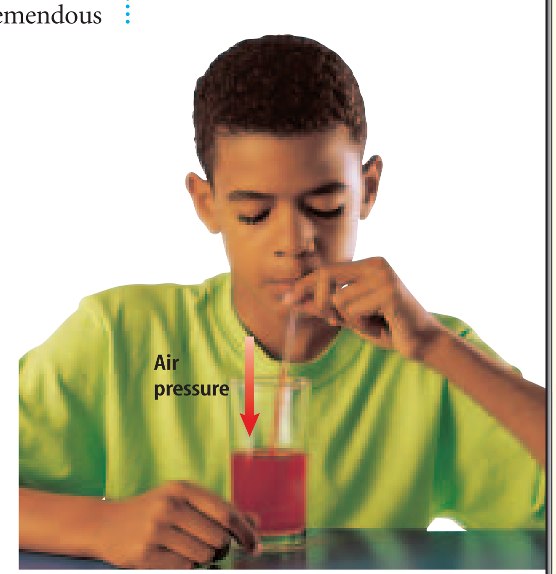
Force and Area You can see from the equation on the opposite page that pressure depends on the quantity of force exerted and the area over which the force is exerted. As the force increases over a given area, pressure increases. If the force decreases, the pressure will decrease. However, if the area changes, the same amount of force can result in different pressure. **Figure 16** shows that if the force of the ballerina's weight is exerted over a smaller area, the pressure increases. If that same force is exerted over a larger area, the pressure will decrease.

Reading Check *What variables does pressure depend on?*

Atmospheric Pressure You can't see it and you usually can't feel it, but the air around you presses on you with tremendous force. The pressure of air also is known as atmospheric pressure because air makes up the atmosphere around Earth. Atmospheric pressure is 101.3 kPa at sea level. This means that air exerts a force of about 101,000 N on every square meter it touches. This is approximately equal to the weight of a large truck.

It might be difficult to think of air as having pressure when you don't notice it. However, you often take advantage of air pressure without even realizing it. Air pressure, for example, enables you to drink from a straw. When you first suck on a straw, you remove the air from it. As you can see in **Figure 17,** air pressure pushes down on the liquid in your glass then forces liquid up into the straw. If you tried to drink through a straw inserted into a sealed, airtight container, you would not have any success because the air would not be able to push down on the surface of the drink.

Figure 17 The downward pressure of air pushes the juice up into the straw.



2 Teach

Caption Answer

Figure 16 The area is different.

Reading Check

Answer force and area

Visual Learning

Figure 17 Have students explain how a drinking straw works. Sucking on the straw creates a difference between the air pressure on the liquid in the cup and the air pressure on the liquid in the straw. The higher pressure outside the straw pushes the liquid up the straw. L2 LS **Visual-Spatial**

Discussion

Snow Skis and Snowshoes How does using snow skis or snowshoes enable a person to ski or walk on soft snow? The skis or snowshoes distribute the force of the person's weight over a larger area, decreasing the pressure exerted on the surface of the snow. L2 LS **Logical-Mathematical**

Science Journal

Pressure Applied Have each student make a drawing of a balloon in his or her Science Journal and show the molecular forces that are keeping the balloon inflated. Ask students to include captions that explain why the balloon stays inflated. After completing the section, have students compare their drawings and explanations with **Figure 19.**
L2 LS **Visual-Spatial** P

Use Science Words

Word Meaning The word *atmosphere* is formed from the word parts *atmos*, which is Greek for "vapor," and *sphaera*, the Latin word for "sphere." Ask students to explain how these word parts are related to the meaning of *atmosphere*. The atmosphere is the gases (or vapors) that surround Earth (a spherical body). L2 LS **Linguistic**

Discussion

Air Pressure Suppose that instead of a balloon you had a sealed box of air. What would happen to the particles of air as you carried the box up the mountain? Explain. Nothing would happen as long as the box was sealed, because the rigid walls of the box would keep the particles in the box isolated from the changes in air pressure outside the box. L3 LS **Logical-Mathematical**

Caption Answer

Figure 18 The pressure of fluids in her body balances atmospheric pressure.

Figure 18 Atmospheric pressure exerts a force on all surfaces of this dancer's body.
Explain *why she can't feel this pressure.*

Balanced Pressure If air is so forceful, why don't you feel it? The reason is that the pressure exerted outward by the fluids in your body balances the pressure exerted by the atmosphere on the surface of your body. Look at **Figure 18.** The atmosphere exerts a pressure on all surfaces of the dancer's body. She is not crushed by this pressure because the fluids in her body exert a pressure that balances atmospheric pressure.

Variations in Atmospheric Pressure Atmospheric pressure changes with altitude. Altitude is the height above sea level. As altitude increases atmospheric pressure decreases. This is because fewer air particles are found in a given volume. Fewer particles have fewer collisions, and therefore exert less pressure. This idea was tested in the seventeenth century by a French physician named Blaise Pascal. He designed an experiment in which he filled a balloon only partially with air. He then had the balloon carried to the top of a mountain. **Figure 19** shows that as Pascal predicted, the balloon expanded while being carried up the mountain. Although the amount of air inside the balloon stayed the same, the air pressure pushing in on it from the outside decreased. Consequently, the particles of air inside the balloon were able to spread out further.

Figure 19 Notice how the balloon expands as it is carried up the mountain. The reason is that atmospheric pressure decreases with altitude. With less pressure pushing in on the balloon, the gas particles within the balloon are free to expand.

Visual Learning

Figure 19 Discuss with students how the balloon would change if the amount of air pressure exerted on it were increased. The gas inside the balloon would be compressed as it was squeezed by increased air pressure acting on the balloon. This would make the balloon get smaller. L2 LS **Logical-Mathematical**

Teacher FYI

Pascal Blaise Pascal lived from 1623 to 1662. As part of his work with fluids, he formulated Pascal's principle, which will be studied later in this chapter. The unit of pressure, the pascal, was named for him.

Air Travel If you travel to higher altitudes, perhaps flying in an airplane or driving up a mountain, you might feel a popping sensation in your ears. As the air pressure drops, the air pressure in your ears becomes greater than the air pressure outside your body. The release of some of the air trapped inside your ears is heard as a pop. Airplanes are pressurized so that the air pressure within the cabin does not change dramatically throughout the course of a flight.

Changes in Gas Pressure

In the same way that atmospheric pressure can vary as conditions change, the pressure of gases in confined containers also can change. The pressure of a gas in a closed container changes with volume and temperature.

Pressure and Volume If you squeeze a portion of a filled balloon, the remaining portion of the balloon becomes more firm. By squeezing it, you decrease the volume of the balloon, forcing the same number of gas particles into a smaller space. As a result, the particles collide with the walls more often, thereby producing greater pressure. This is true as long as the temperature of the gas remains the same. You can see the change in the motion of the particles in **Figure 20.** What will happen if the volume of a gas increases? If you make a container larger without changing its temperature, the gas particles will collide less often and thereby produce a lower pressure.

Mini LAB

Predicting a Waterfall

Procedure

1. Fill a **plastic cup** to the brim with **water.**
2. Cover the top of the cup with an **index card.**
3. Predict what will happen if you turn the cup upside down.
4. While holding the index card in place, turn the cup upside down over a sink. Then let go of the card.

Analysis

1. What happened to the water when you turned the cup?
2. How can you explain your observation in terms of the concept of fluid pressure?

Try at Home

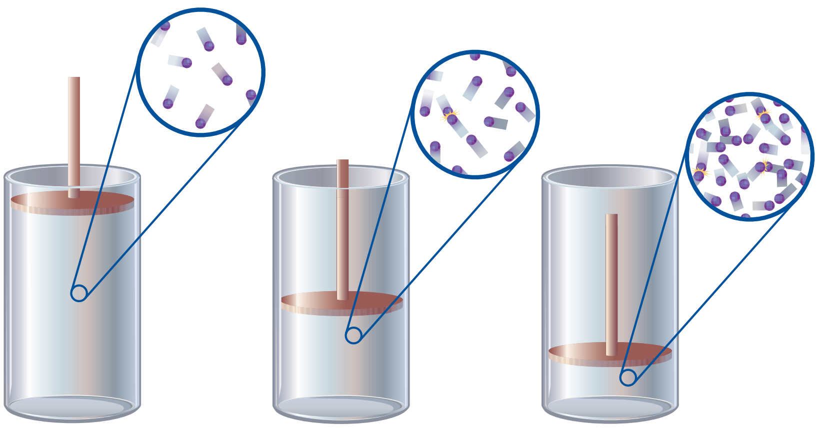


Figure 20 As volume decreases, pressure increases.

As the piston is moved down, the gas particles have less space and collide more often. The pressure increases.

Mini LAB

Purpose to observe how air pressure produces enough force to hold water in a cup L2 ELL COOP LEARN LS **Kinesthetic**

Materials plastic cup, water, index card

Teaching Strategy Tell students to try not to let any water out of the cup as they turn it over.

Troubleshooting The card must be able to make a tight seal with the cup in order for this experiment to work. Any cup used should have a continuously smooth rim.

Analysis

1. The water remained in the cup.
2. The pressure of the molecules in the air pushing up on the card was greater than the pressure of the water pushing down on the card.

Assessment

Process Ask students to form a hypothesis concerning what will happen if some air is included in the cup. Have them try the experiment. As long as the cup contains enough water to make a seal between the rim and the card, the card will remain in place. Use **Performance Assessment in the Science Classroom,** p. 93.

Try at Home

Fun Fact

Relationships between temperature, pressure, and volume in a gas sample were defined by Jacques Charles and Robert Boyle. Charles's law relates temperature and volume. Boyle's law relates pressure and volume.

Activity

Warming Gas Provide students with balloons. Have them blow up the balloons and tie them shut. Ask each student to measure the circumference of his or her balloon at its widest point, then hold it over a lit lightbulb for a few minutes and measure the circumference again. What happened to the balloon as it was warmed by the lightbulb? The gas particles inside it started moving faster, pushing out on the balloon and causing it to expand. Extend the activity by placing one or two balloons in the freezer for a short while. L2 LS **Kinesthetic**

Caption Answer

Figure 21 The container will explode.

Reading Check

Answer As temperature decreases, pressure decreases. This makes the pressure inside the container lower than the pressure outside the container. The external pressure pushes the container inward.

Discussion

Buoyant Force What do you think will happen if the buoyant force in a fluid is equal to the weight of an object in it? The object will remain suspended in the fluid, neither rising nor falling. L3 LS **Logical-Mathematical**

Quick Demo

Cartesian Diver

Materials beaker, squeeze condiment packet such as ketchup or soy sauce, empty 2-L bottle with cap, water

Estimated Time 15 minutes

Procedure Fill a beaker with water. Place several types of unopened condiment packets in the water. The one that barely floats will be used for the next step. Fill the 2-L bottle with water to the very top of the bottle. Insert the unopened condiment packet from the first step. Replace the cap on the bottle. Squeezing the bottle will make the condiment packet sink to the bottom. Release the bottle and the packet rises.

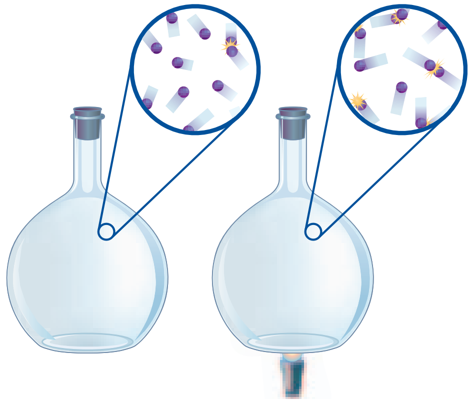


Figure 21 Even though the volume of this container does not change, the pressure increases as the substance is heated.
Describe *what will happen if the substance is heated too much.*

Pressure and Temperature When the volume of a confined gas remains the same, the pressure can change as the temperature of the gas changes. You have learned that temperature rises as the kinetic energy of the particles in a substance increases. The greater the kinetic energy is, the faster the particles move. The faster the speed of the particles is, the more they collide and the greater the pressure is. If the temperature of a confined gas increases, the pressure of the gas will increase, as shown in **Figure 21.**

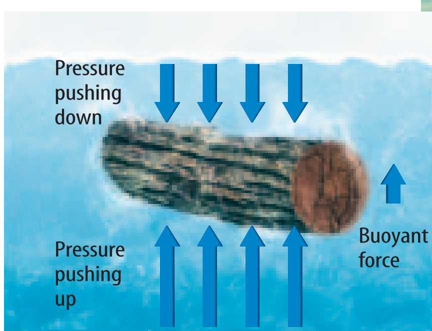
Reading Check *Why would a sealed container of air be crushed after being frozen?*

Float or Sink

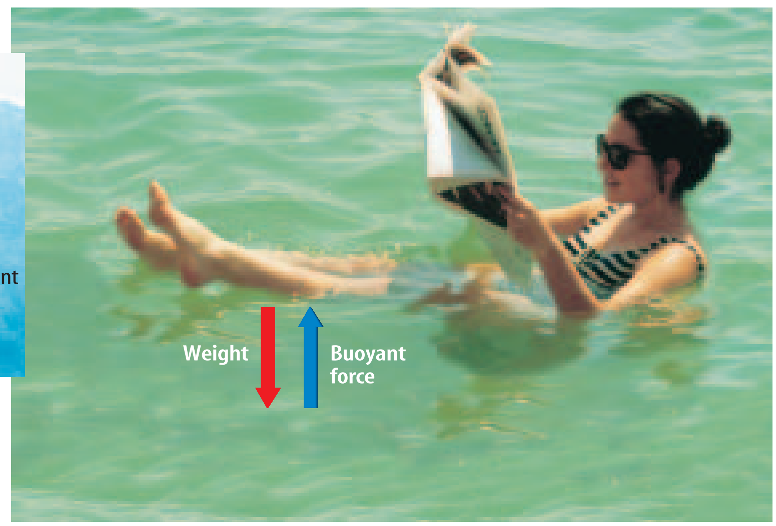
You may have noticed that you feel lighter in water than you do when you climb out of it. While you are under water, you experience water pressure pushing on you in all directions. Just as air pressure increases as you walk down a mountain, water pressure increases as you swim deeper in water. Water pressure increases with depth. As a result, the pressure pushing up on the bottom of an object is greater than the pressure pushing down on it because the bottom of the object is deeper than the top.

The difference in pressure results in an upward force on an object immersed in a fluid, as shown in **Figure 22.** This force is known as the **buoyant force.** If the buoyant force is equal to the weight of an object, the object will float. If the buoyant force is less than the weight of an object, the object will sink.

Figure 22 The pressure pushing up on an immersed object is greater than the pressure pushing down on it. This difference results in the buoyant force.



Weight is a force in the downward direction. The buoyant force is in the upward direction. An object will float if the upward force is equal to the downward force.



Differentiated Instruction

Challenge Have students construct a neutrally buoyant helium balloon and gondola—one that has the same density as air. When you test the balloon, make sure there are no drafts in the room. Students will have succeeded if the balloon and gondola remain stationary between the ceiling and floor of a room for several minutes or if they ascend or descend slowly. L3 LS **Kinesthetic**

Archimedes' Principle What determines the buoyant force? According to **Archimedes' (ar kuh MEE deez) principle,** the buoyant force on an object is equal to the weight of the fluid displaced by the object. In other words, if you place an object in a beaker that already is filled to the brim with water, some water will spill out of the beaker, as in **Figure 23.** If you weigh the spilled water, you will find the buoyant force on the object.

Density Understanding density can help you predict whether an object will float or sink. **Density** is mass divided by volume.

$$\text{density} = \frac{\text{mass}}{\text{volume}}$$

An object will float in a fluid that is more dense than itself and sink in a fluid that is less dense than itself. If an object has the same density, the object will neither sink nor float but instead stay at the same level in the fluid.

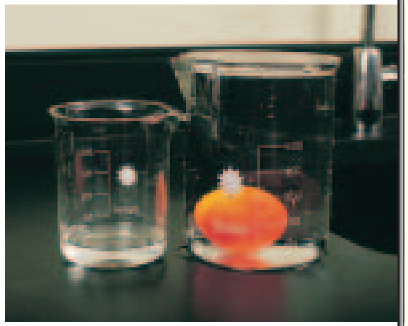


Figure 23 When the golf ball was dropped in the large beaker, it displaced some of the water, which was collected and placed into the smaller beaker.
Communicate *what you know about the weight and the volume of the displaced water.*

Applying Math — Find an Unknown

CALCULATING DENSITY You are given a sample of a solid that has a mass of 10.0 g and a volume of 4.60 cm^3. Will it float in liquid water, which has a density of 1.00 g/cm^3?

Solution

1 *This is what you know:*
- mass = 10.0 g
- volume = 4.60 cm^3
- density of water = 1.00 g/cm^3

2 *This is what you need to find:* the density of the sample

3 *This is the procedure you need to use:*
- density = mass/volume
- density = 10.0 g/4.60 cm^3 = 2.17 g/cm^3
- The density of the sample is greater than the density of water. The sample will sink.

4 *Check your answer:*
- Find the mass of your sample by multiplying the density and the volume.

Practice Problems

1. A 7.40-cm^3 sample of mercury has a mass of 102 g. Will it float in water?
2. A 5.0-cm^3 sample of aluminum has a mass of 13.5 g. Will it float in water?

Science Online — For more practice, visit ips.msscience.com/math_practice

Caption Answer

Figure 23 The volume of the displaced water equals the volume of the golf ball. The weight of the displaced water is less than the weight of the golf ball.

Activity

Soft-Drink Mass Obtain unopened aluminum cans of regular and diet versions of a soft drink. Show the class that the volumes of the cans are equal. Have students predict what will happen when the cans are placed in a sink or aquarium filled with water. Place the cans into the water and observe. The can of diet drink floats, while the can of regular drink sinks. Divide the class in half and have each group measure the masses of the cans with a balance. Ask how the masses compare. The regular drink is heavier. Discuss with students the idea that equal volumes of different substances can have different masses. Explain that the difference in mass is due to sugar. L2 ELL LS **Kinesthetic**

Applying Math

National Math Standards

Correlation to Mathematics Objectives

1, 6, 7

Teaching Strategy

This is what you know: mass = 102 g, volume = 7.40 cm^3, density of water = 1.00 g/cm^3

This is what you need to find: density of the sample.

This is the equation you need to use: density = mass/volume

Substitute in the known values: density = 102 g/7.40 cm^3 = 13.78 g/cm^3

Answers to Practice Problems

1. No; the density of mercury, which is 13.8 g/cm^3, is greater than the density of water.
2. No; density of aluminum, which is 2.7 g/cm^3, is greater than the density of water.

Curriculum Connection

History Archimedes was one of history's most gifted mathematicians. He very nearly invented calculus, but did not have the notation to describe his ideas. According to legend, he came to an unfortunate end when he yelled at an invading Roman soldier for ruining calculations he was writing in the dirt. The unappreciative soldier killed him with his sword. Have students find out when Archimedes lived. 287–212 B.C. L2

Differentiated Instruction

Learning Disabled Demonstrate to students how density affects the buoyant force. Have two beakers full of the same amount of water. In one beaker add pieces of styrofoam. In the other add several pennies. Ask students to explain why the styrofoam floated, but the pennies sank.

Inquiry Lab

Observing Density

Purpose to explore and observe density by making miniature lava lamps

Possible Materials glass jar or clear drinking glass, vegetable oil, salt, water, food coloring

Estimated Time 20 minutes

Teaching Strategies

- Students make simple lava lamps by pouring about 7.5 cm of water in the bottom of the jar. Then have them pour about 78 mL of vegetable oil into the jar. Add food coloring.
- Students should shake salt on top of oil while slowly counting to 5.

Observe

What happened when salt is added to the oil? Salt is more dense than water. When salt is poured on the oil, it sinks to the bottom of the mixture, carrying some of the oil with it. In the water layer, the salt starts to dissolve. As it dissolves, the oil is released and floats back up to the top of the water.

For additional inquiry activities, see *Science Inquiry Labs*.

Discussion

Ear Pressure Challenge students to use Pascal's principle to explain why their ears may hurt when they swim to the bottom of the deepest part of a swimming pool. The weight of the water above makes the pressure at the bottom of the pool greater than that at the surface. L2

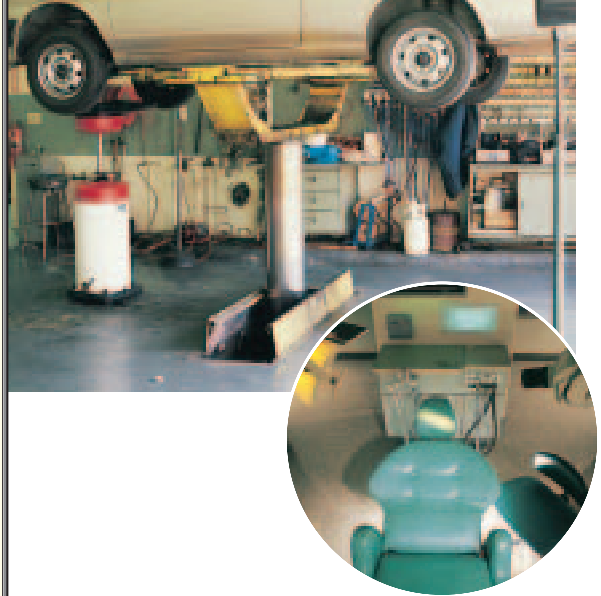


Figure 24 A hydraulic lift utilizes Pascal's principle to help lift this car and this dentist's chair.

Pascal's Principle

What happens if you squeeze a plastic container filled with water? If the container is closed, the water has nowhere to go. As a result, the pressure in the water increases by the same amount everywhere in the container—not just where you squeeze or near the top of the container. When a force is applied to a confined fluid, an increase in pressure is transmitted equally to all parts of the fluid. This relationship is known as **Pascal's principle.**

Hydraulic Systems You witness Pascal's principle when a car is lifted up to have its oil changed or if you are in a dentist's chair as it is raised or lowered, as shown in **Figure 24.** These devices, known as hydraulic (hi DRAW lihk) systems, use Pascal's principle to increase force. Look at the tube in **Figure 25.** The force applied to the piston on the left increases the pressure within the fluid. That increase in pressure is transmitted to the piston on the right. Recall that pressure is equal to force divided by area. You can solve for force by multiplying pressure by area.

$$\text{pressure} = \frac{\text{force}}{\text{area}} \quad \text{or} \quad \text{force} = \text{pressure} \times \text{area}$$

If the two pistons on the tube have the same area, the force will be the same on both pistons. If, however, the piston on the right has a greater surface area than the piston on the left, the resulting force will be greater. The same pressure multiplied by a larger area equals a greater force. Hydraulic systems enable people to lift heavy objects using relatively small forces.

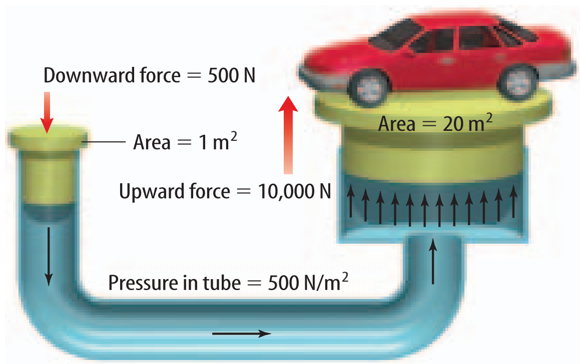


Figure 25 By increasing the area of the piston on the right side of the tube, you can increase the force exerted on the piston. In this way a small force pushing down on the left piston can result in a large force pushing up on the right piston. The force can be great enough to lift a car.

Cultural Diversity

Force Pumps Simple piston-type force pumps were known throughout the ancient world. The more efficient double-acting piston bellows were developed by the Chinese, and did not reach Europe until the 1500s. In this device, fluid is pulled in through intake valves on either side and pushed out through a nozzle on both strokes of the piston.

Visual Learning

Figure 25 Review with students the process shown in this figure. Remind students that work equals force times distance. In a hydraulic lift, the force applied to the smaller piston is small, but it is applied over a long distance, so the work done on each side of the lift is the same. L2 LS **Visual-Spatial**

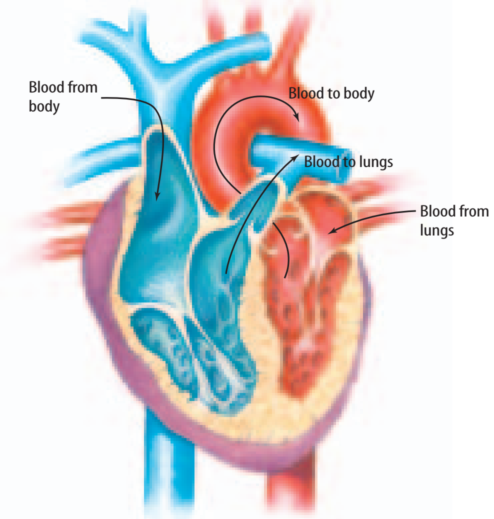


Figure 26 The heart is responsible for moving blood throughout the body. Two force pumps work together to move blood to and from the lungs and to the rest of the body.

Force Pumps If an otherwise closed container has a hole in it, any fluid in the container will be pushed out the opening when you squeeze it. This arrangement, known as a force pump, makes it possible for you to squeeze toothpaste out of a tube or mustard from a plastic container.

INTEGRATE Life Science

Your heart has two force pumps. One pump pushes blood to the lungs, where it picks up oxygen. The other force pump pushes the oxygen-rich blood to the rest of your body. These pumps are shown in **Figure 26.**

Science Online

Topic: Blood Pressure

Visit ips.msscience.com for Web links to information about blood pressure. Find out what the term means, how it changes throughout the human body, and why it is unhealthy to have high blood pressure.

Activity Write a paragraph in your Science Journal that explains why high blood pressure is dangerous.

section 3 review

Summary

Pressure

- Pressure depends on force and area.
- The air around you exerts a pressure.
- The pressure inside your body matches the pressure exerted by air.

Changes in Gas Pressure

- The pressure exerted by a gas depends on its volume and its temperature.

Float or Sink

- Whether an object floats or sinks depends on its density relative to the density of the fluid it's in.

Pascal's Principle

- This principle relates pressure and area to force.

Self Check

1. **Describe** what happens to pressure as the force exerted on a given area increases.
2. **Describe** how atmospheric pressure changes as altitude increases.
3. **State** Pascal's principle in your own words.
4. **Infer** An object floats in a fluid. What can you say about the buoyant force on the object?
5. **Think Critically** All the air is removed from a sealed metal can. After the air has been removed, the can looks as if it were crushed. Why?

Applying Math

6. **Simple Equations** What pressure is created when 5.0 N of force are applied to an area of 2.0 m^2? How does the pressure change if the force is increased to 10.0 N? What about if instead the area is decreased to 1.0 m^2?

Science Online ips.msscience.com/self_check_quiz

3 Assess

DAILY INTERVENTION

Check for Understanding

Logical-Mathematical Have students predict what would happen if a rock punched a small hole in the bottom of an airtight compartment in a ship. As long as no air escaped, the pressure of the air in the compartment would allow little water into the compartment. L3 LS

Reteach

Fluids Organize the class into four groups. Assign each group pressure, density, Archimedes' principle, or Pascal's principle. Have each group present to the class its understanding of the assigned term. Each group should be able to define the term and give examples illustrating it. L2 COOP LEARN LS **Interpersonal**

Assessment

Process Place a beaker of water, a beaker of alcohol, and a beaker of ethylene glycol in front of the class. Challenge students to use buoyancy to put the liquids in order from lowest density to highest density. Students may immerse objects in the liquids to determine the relative densities of the liquids. Use **Performance Assessment in the Science Classroom,** p. 97.

section 3 review

1. Pressure increases.
2. Atmospheric pressure decreases.
3. When a force is applied to a confined fluid, an increase in pressure is transmitted equally to all parts of the fluid.
4. The buoyant force is greater than the weight of the object.
5. After the air is removed, the atmospheric pressure on the outside of the can is greater than the pressure on the inside of the can, so the can collapses.
6. 2.5 Pa; the pressure increases to 5 Pa. If the force is 5.0 N and the area is decreased to 1.0 m^2, the pressure increases to 5 Pa.

BENCH TESTED

Real-World Question

Purpose Students apply Archimedes' principle to shipbuilding. L2 COOP LEARN ELL

LS **Logical-Mathematical**

Process Skills observe and infer, design an experiment to test a hypothesis, interpret data, separate and control variables, predict, use numbers

Time Required 90 minutes

Materials balance, 2 small plastic cups, graduated cylinder, metric ruler, scissors, marbles, sink

Alternate Materials basin, pan, or bucket

Form a Hypothesis

Possible Hypothesis Students might hypothesize that a boat floats when the displaced water weighs the same as or more than the boat and its cargo.

Test Your Hypothesis

Possible Procedure Find the mass of the cup and the marbles. Use the density of water (1.00 g/mL) to calculate the volume of water that has the same mass as the cup and marbles, which is the volume of water the boat must displace. Fill the cup with the amount of water that has the same mass as the cup and marbles. Draw a line around the cup at the water line, empty the water, trim the cup to size, and dry the cup. Put the cup into the water in the sink or basin and carefully load the marbles and the trimmed pieces of cup into the floating cup.

LAB **Design Your Own**

Design Your Own Ship

Goals

- **Design** an experiment that uses Archimedes' principle to determine the size of ship needed to carry a given amount of cargo in such a way that the top of the ship is even with the surface of the water.

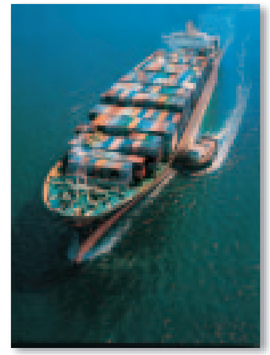
Possible Materials

balance
small plastic cups (2)
graduated cylinder
metric ruler
scissors
marbles (cupful)
sink
**basin, pan, or bucket*
**Alternate materials*

Safety Precautions

Real-World Question

It is amazing to watch ships that are taller than buildings float easily on water. Passengers and cargo are carried on these ships in addition to the tremendous weight of the ship itself. How can you determine the size of a ship needed to keep a certain mass of cargo afloat?



Cargo ship

Form a Hypothesis

Think about Archimedes' principle and how it relates to buoyant force. Form a hypothesis to explain how the volume of water displaced by a ship relates to the mass of cargo the ship can carry.

Test Your Hypothesis

Make a Plan

1. Obtain a set of marbles or other items from your teacher. This is the cargo that your ship must carry. Think about the type of ship

124

Alternative Inquiry Lab

Explore Further To extend this Lab into an Inquiry Lab, have students think of similarities and differences between designing a water boat and an airship. What would an airship be filled with? lighter-than-air gases or hot air, like a hot air balloon What shape, material, and design differences are there? Students may enjoy tracing the history of airships, including their role in World War II, researching the different kinds of airships and technologies used in their engineering and construction, and/or experimenting with commercial helium-filled balloons to see how much weight they can carry.

you will design. Consider the types of materials you will use. Decide how your group is going to test your hypothesis.

2. **List** the steps you need to follow to test your hypothesis. Include in your plan how you will measure the mass of your ship and cargo, calculate the volume of water your ship must displace in order to float with its cargo, and measure the volume and mass of the displaced water. Also, explain how you will design your ship so that it will float with the top of the ship even with the surface of the water. Make the ship.
3. **Prepare** a data table in your Science Journal to use as your group collects data. Think about what data you need to collect.

Follow Your Plan

1. Make sure your teacher approves your plan before you start.
2. Perform your experiment as planned. Be sure to follow all proper safety procedures. In particular, clean up any spilled water immediately.
3. Record your observations carefully and complete the data table in your Science Journal.

Analyze Your Data

1. **Write** your calculations showing how you determined the volume of displaced water needed to make your ship and cargo float.
2. Did your ship float at the water's surface, sink, or float above the water's surface? Draw a diagram of your ship in the water.
3. **Explain** how your experimental results agreed or failed to agree with your hypothesis.

Conclude and Apply

1. If your ship sank, how would you change your experiment or calculations to correct the problem? What changes would you make if your ship floated too high in the water?
2. What does the density of a ship's cargo have to do with the volume of cargo the ship can carry? What about the density of the water?

Communicating Your Data

Compare your results with other students' data. Prepare a combined data table or summary showing how the calculations affect the success of the ship. **For more help, refer to the Science Skill Handbook.**

Teaching Strategies

- Before conducting the experiment, review density and its relationship to buoyancy.
- Students should not put the marbles into the boats until they are ready to test their boats.

Expected Outcome Students' data tables should include spaces for the mass of the cup and marbles, the volume of water the cup must displace, measurements of the cup, any calculations of the cup's volume, and the results of the experiment.

Analyze Your Data

Answers to Questions

1. Typical calculations will involve relating the mass of the cargo and boat to the volume of the water displaced.
2. Results will vary.
3. Answers will vary, but should include the problems or successes that resulted when using their hypothesis.

Error Analysis

Students should explain why the boat sank or floated too high in the water and identify the problems.

Conclude and Apply

1. Answers will vary. Either way, students should check their measurements and calculations.
2. A ship can carry only a certain mass of cargo safely. Therefore, the ship can carry less high-density cargo than low-density cargo. If the water density is greater than 1 g/mL, then the volume that the ship can carry will be less. If the water density is less, then the ship can carry more volume.

Assessment

Oral Have students explain why ships are designed to be taller than their anticipated cargo requires. If the ship has no excess height, waves could wash over the ship's side easily or excess cargo could be loaded onto the ship, sinking the ship. Use **Performance Assessment in the Science Classroom,** p. 89.

Communicating Your Data

Suggest students use a spreadsheet program for preparing combined data tables.

Content Background

Silicon is the second most abundant element in Earth's crust. Rubber is a natural carbon-based polymer that comes from trees. Polymers are large molecules made from many small molecules linked together. During World War II, scientists were trying to replace carbon in organic molecules such as rubber with silicon. Silicones are polymers made up of silicon atoms linked to oxygen atoms. Various organic compounds are often attached to the polymer to control and change its physical properties. Some silicones form rubbery elastic compounds, while others are designed to act as lubricants.

Activity

Make Your Own "Goo" Allow small groups of students to investigate how the addition of a compound can change the properties of a polymer. Dissolve 2 mL of borax in 125 mL of water in a beaker. Have students pour 15 mL of white glue (a polymer) into a paper cup. Then have them add 15 mL of the borax solution to the glue and stir it with a craft stick. The borax cross-links the glue polymers, making the resulting compound thicker and more rubbery. Tell students to remove the polymer from the cup and knead it for a few minutes. As a class, discuss the properties of the new polymer. L2 LS **Kinesthetic**

Analyze the Event

Why do this? Ask students to brainstorm possible reasons scientists tried unusual experiments when working to come up with an inexpensive alternative to synthetic rubber.

Oops! Accidents in SCIENCE

SOMETIMES GREAT DISCOVERIES HAPPEN BY ACCIDENT!

The Incredible Stretching Goo

A serious search turns up a toy

During World War II, when natural resources were scarce and needed for the war effort, the U.S. government asked an engineer to come up with an inexpensive alternative to synthetic rubber. While researching the problem and looking for solutions, the engineer dropped boric acid into silicone oil. The result of these two substances mixing together was—a goo!

Because of its molecular structure, the goo could bounce and stretch in all directions. The engineer also discovered the goo could break into pieces. When strong pressure is applied to the substance, it reacts like a solid and breaks apart. Even though the combination was versatile—and quite amusing, the U.S. government decided the new substance wasn't a good substitute for synthetic rubber.

A few years later, the recipe for the stretch material fell into the hands of a businessperson, who saw the goo's potential—as a toy. The toymaker paid $147 for rights to the boric acid and silicone oil mixture. And in 1949 it was sold at toy stores for the first time. The material was packaged in a plastic egg and it took the U.S. by storm. Today, the acid and oil mixture comes in a multitude of colors and almost every child has played with it at some time.

The substance can be used for more than child's play. Its sticky consistency makes it good for cleaning computer keyboards and removing small specks of lint from fabrics.

People use it to make impressions of newspaper print or comics. Athletes strengthen their grips by grasping it over and over. Astronauts use it to anchor tools on spacecraft in zero gravity. All in all, a most *eggs-cellent* idea!

Research As a group, examine a sample of the colorful, sticky, stretch toy made of boric acid and silicone oil. Then brainstorm some practical—and impractical—uses for the substance.

Science Online
For more information, visit ips.msscience.com/oops

Research Ask students in each group to describe the list of uses they came up with for the goo. Ask students in other groups to comment on whether or not they think the proposed uses would actually work. If possible, allow students to demonstrate some of the uses they brainstormed. L2

Resources for Teachers and Students

Super Science Concoctions, by Jill Frankel Hauser, Williamson Publishing, 1997

They All Laughed . . . From Light Bulbs to Lasers: The Fascinating Stories Behind Great Inventions That Have Changed Our Lives, by Ira Flatow, Harper Perennial, 1992

Reviewing Main Ideas

Section 1 Matter

1. All matter is composed of tiny particles that are in constant motion.
2. In the solid state, the attractive force between particles holds them in place to vibrate.
3. Particles in the liquid state have defined volumes and are free to move about within the liquid.

Section 2 Changes of State

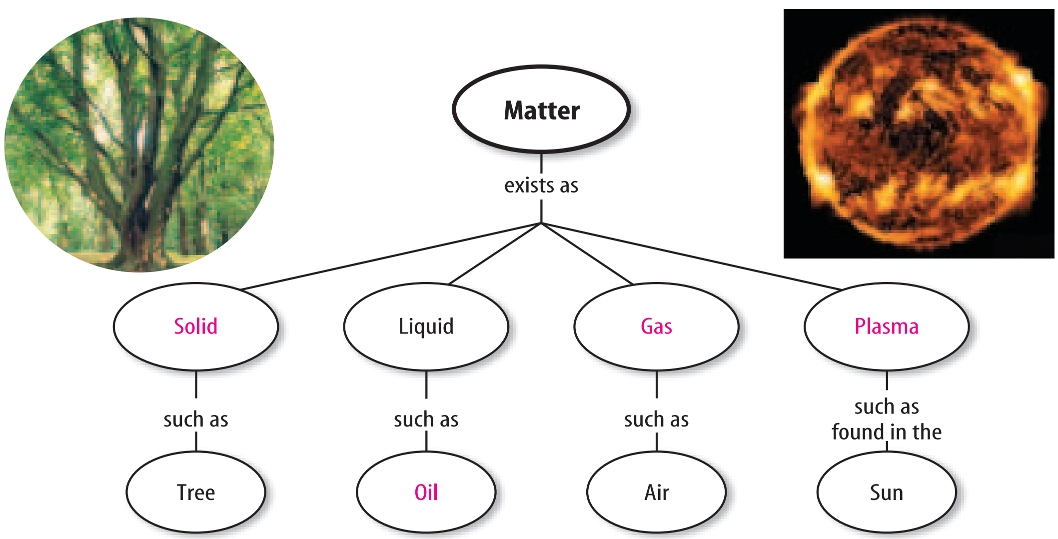
1. Thermal energy is the total energy of the particles in a sample of matter. Temperature is the average kinetic energy of the particles in a sample.
2. An object gains thermal energy when it changes from a solid to a liquid, or when it changes from a liquid to a gas.
3. An object loses thermal energy when it changes from a gas to a liquid, or when it changes from a liquid to a solid.

Section 3 Behavior of Fluids

1. Pressure is force divided by area.
2. Fluids exert a buoyant force in the upward direction on objects immersed in them.
3. An object will float in a fluid that is more dense than itself.
4. Pascal's principle states that pressure applied to a liquid is transmitted evenly throughout the liquid.

Visualizing Main Ideas

Copy and complete the following concept map on matter.



Identifying Misconceptions

Assess

Use the assessment as follow-up to page F at the beginning of the chapter after students have completed the chapter.

Materials paper, pencil

Procedure Have students work in groups to make cartoon posters of sporting events in which the Matter Team plays the Non-Matter Team. Students should choose a team sport and create each team. For instance in a baseball game there can be an Iron Infielder and Plastic Pitcher on the Matter Team and Light Left fielder and Kinetic Energy Catcher on the Non-Matter Team. L2

Expected Outcome Students should realize that matter includes solids, liquids, and gases and does not include types of energy.

chapter 4 Study Guide

Reviewing Main Ideas

Summary statements can be used by students to review the major concepts of the chapter.

Visualizing Main Ideas

See student page.

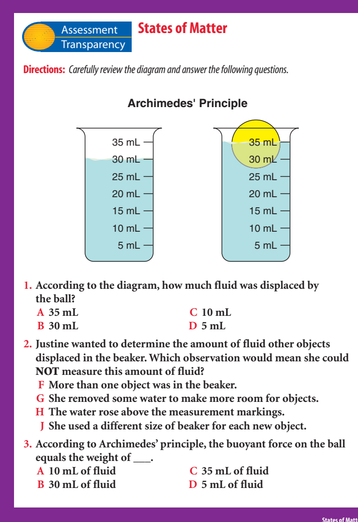
Science Online

Visit ips.msscience.com
/self_check_quiz
/interactive_tutor
/vocabulary_puzzlemaker
/chapter_review
/standardized_test

Assessment Transparency

For additional assessment questions, use the *Assessment Transparency* located in the transparency book.

Assessment


Assessment Transparency **States of Matter**

Directions: *Carefully review the diagram and answer the following questions.*

Archimedes' Principle

1. According to the diagram, how much fluid was displaced by the ball?
   A 35 mL C 10 mL
   B 30 mL D 5 mL
2. Justine wanted to determine the amount of fluid other objects displaced in the beaker. Which observation would mean she could **NOT** measure this amount of fluid?
   F More than one object was in the beaker.
   G She removed some water to make more room for objects.
   H The water rose above the measurement markings.
   J She used a different size of beaker for each new object.
3. According to Archimedes' principle, the buoyant force on the ball equals the weight of ___.
   A 10 mL of fluid C 35 mL of fluid
   B 30 mL of fluid D 5 mL of fluid

States of Matter

Using Vocabulary

1. gas
2. liquid
3. Heat
4. Temperature
5. condensation
6. vaporization
7. Density
8. Pressure
9. Pascal's Principle

Checking Concepts

10. B	16. D
11. A	17. B
12. C	18. C
13. D	19. C
14. B	20. B
15. C	

chapter 4 Review

Using Vocabulary

Archimedes' principle p. 121	melting p. 109
buoyant force p. 120	Pascal's principle p. 122
condensation p. 113	pressure p. 116
density p. 121	solid p. 103
freezing p. 111	surface tension p. 105
gas p. 106	temperature p. 108
heat p. 108	thermal energy p. 107
liquid p. 104	vaporization p. 112
matter p. 102	viscosity p. 105

Fill in the blanks with the correct vocabulary word.

1. A(n) ________ can change shape and volume.
2. A(n) ________ has a different shape but the same volume in any container.
3. ________ is thermal energy moving from one substance to another.
4. ________ is a measure of the average kinetic energy of the particles of a substance.
5. A substance changes from a gas to a liquid during the process of ________.
6. A liquid becomes a gas during ________.
7. ________ is mass divided by volume.
8. ________ is force divided by area.
9. ________ explains what happens when force is applied to a confined fluid.

Checking Concepts

Choose the word or phrase that best answers the question.

10. Which of these is a crystalline solid?
    A) glass
    B) sugar
    C) rubber
    D) plastic

11. Which description best describes a solid?
    A) It has a definite shape and volume.
    B) It has a definite shape but not a definite volume.
    C) It adjusts to the shape of its container.
    D) It can flow.

12. What property enables you to float a needle on water?
    A) viscosity
    B) temperature
    C) surface tension
    D) crystal structure

13. What happens to an object as its kinetic energy increases?
    A) It holds more tightly to nearby objects.
    B) Its mass increases.
    C) Its particles move more slowly.
    D) Its particles move faster.

14. During which process do particles of matter release energy?
    A) melting
    B) freezing
    C) sublimation
    D) boiling

15. How does water vapor in air form clouds?
    A) melting
    B) evaporation
    C) condensation
    D) sublimation

16. Which is a unit of pressure?
    A) N
    B) kg
    C) g/cm^3
    D) N/m^2

17. Which change results in an increase in gas pressure in a balloon?
    A) decrease in temperature
    B) decrease in volume
    C) increase in volume
    D) increase in altitude

18. In which case will an object float on a fluid?
    A) Buoyant force is greater than weight.
    B) Buoyant force is less than weight.
    C) Buoyant force equals weight.
    D) Buoyant force equals zero.

Science Online ips.msscience.com/vocabulary_puzzlemaker

Use the *ExamView® Assessment Suite* CD-ROM to:

- create multiple versions of tests
- create modified tests with one mouse click for inclusion students
- edit existing questions and add your own questions
- build tests aligned with state standards using built-in State Curriculum Tags
- change English tests to Spanish with one mouse click and vice versa

Use the photo below to answer question 19.

19. In the photo above, the water in the small beaker was displaced when the golf ball was added to the large beaker. What principle does this show?
A) Pascal's principle
B) the principle of surface tension
C) Archimedes' principle
D) the principle of viscosity

20. Which is equal to the buoyant force on an object?
A) volume of the object
B) weight of the displaced fluid
C) weight of object
D) volume of fluid

Thinking Critically

21. Explain why steam causes more severe burns than boiling water.

22. Explain why a bathroom mirror becomes fogged while you take a shower.

23. Form Operational Definitions Write operational definitions that explain the properties of and differences among solids, liquids, and gases.

24. Determine A king's crown has a volume of 110 cm^3 and a mass of 1,800 g. The density of gold is 19.3 g/cm^3. Is the crown pure gold?

25. Infer Why do some balloons pop when they are left in sunlight for too long?

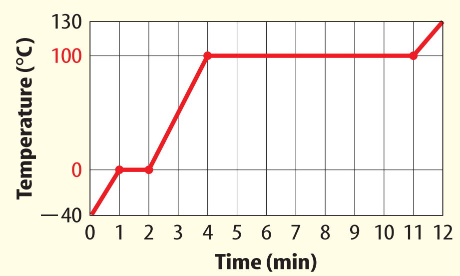
Performance Activities

26. Storyboard Create a visual-aid storyboard to show ice changing to steam. There should be a minimum of five frames.

Applying Math

Use the graph below to answer question 27.

Vaporization of Water



27. Explain how this graph would change if a greater volume of water were heated. How would it stay the same?

Use the table below to answer question 28.

Water Pressure

Depth (m)	Pressure (atm)	Depth (m)	Pressure (atm)
0	1.0	100	11.0
25	3.5	125	13.5
50	6.0	150	16.0
75	8.5	175	18.5

28. Make and Use Graphs In July of 2001, Yasemin Dalkilic of Turkey dove to a depth of 105 m without any scuba equipment. Make a depth-pressure graph for the data above. Based on your graph, how does water pressure vary with depth? Note: The pressure at sea level, 101.3 kPa, is called one atmosphere (atm).

chapter 4 Review

Thinking Critically

21. Steam contains more thermal energy than boiling water.

22. Some of the hot water from the shower evaporates into the air. It condenses on the mirror because the mirror is cooler than the air.

23. Solids are materials with particles that are very close together. Solids have a definite shape and volume and can be crystalline or amorphous. Liquids are materials in which particles are farther apart than in solids. The individual particles in liquids can flow past each other and have an attraction to each other that gives liquids viscosity and surface tension. Liquids have a definite volume and take the shape of their containers. Gases have particles that are very far apart, move quickly, and lack an attraction to each other. Gases have no definite shape or volume.

24. The density of the king's crown is 16.4 g/cm^3. The crown is not pure gold because its density is less than 19.3 g/cm^3.

25. The pressure of the gas inside the balloon increases as the air in the balloon heats up.

Performance Activities

26. Ice should change first to liquid water, then to steam as heat is added to the system and the water molecules move faster. Use **PASC,** p. 135.

Applying Math

National Math Standards

5, 10

27. The melting and boiling points would remain the same. However, the temperature would rise more slowly and the time required for melting and boiling would increase. Therefore, the slopes during the temperature increases would be less.

28. Water pressure increases as the depth increases.

Assessment Resources

Reproducible Masters

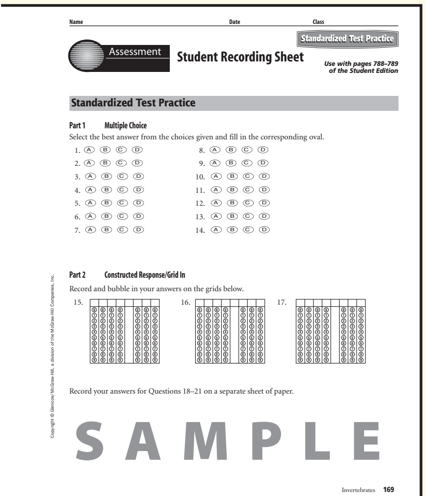
Chapter *Fast File* Resources
Chapter Review, pp. 37–88
Chapter Tests, pp. 39–42
Assessment Transparency Activity, p. 49

Glencoe Science Web site
Chapter Review Test
Standardized Test Practice

Glencoe Technology
Assessment Transparency
ExamView® Assessment Suite
MindJogger Videoquiz
Interactive Chalkboard

FAST FILE

Answer Sheet A practice answer sheet can be found at ips.msscience.com/answer_sheet.


Name Date Class

Assessment Student Recording Sheet

Standardized Test Practice

Use with pages 788–789 of the Student Edition

Standardized Test Practice

Part 1 Multiple Choice

Select the best answer from the choices given and fill in the corresponding oval.

Part 2 Constructed Response/Grid In

Record and bubble in your answers on the grids below.

Record your answers for Questions 18–21 on a separate sheet of paper.

SAMPLE

Part 1 Multiple Choice

1. C
2. A
3. D
4. A
5. C
6. B
7. C
8. B
9. B

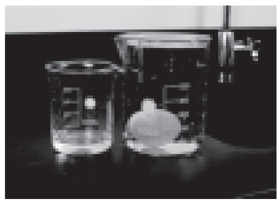
chapter 4 Standardized Test Practice

Part 1 Multiple Choice

Record your answers on the answer sheet provided by your teacher or on a sheet of paper.

1. In which state of matter do particles stay close together, yet are able to move past one another?
A. solid **C.** liquid
B. gas **D.** plasma

Use the illustration below to answer questions 2 and 3.



2. Which statement is true about the volume of the water displaced when the golf ball was dropped into the large beaker?
A. It is equal to the volume of the golf ball.
B. It is greater than the volume of the golf ball.
C. It is less than the volume of the golf ball.
D. It is twice the volume of a golf ball.

3. What do you know about the buoyant force on the golf ball?
A. It is equal to the density of the water displaced.
B. It is equal to the volume of the water displaced.
C. It is less than the weight of the water displaced.
D. It is equal to the weight of the water displaced.

4. What is the process called when a gas cools to form a liquid?
A. condensation **C.** boiling
B. sublimation **D.** freezing

5. Which of the following is an amorphous solid?
A. diamond **C.** glass
B. sugar **D.** sand

6. Which description best describes a liquid?
A. It has a definite shape and volume.
B. It has a definite volume but not a definite shape.
C. It expands to fill the shape and volume of its container.
D. It cannot flow.

7. During which processes do particles of matter absorb energy?
A. freezing and boiling
B. condensation and melting
C. melting and vaporization
D. sublimation and freezing

Use the illustration below to answer questions 8 and 9.

8. What happens as the piston moves down?
A. The volume of the gas increases.
B. The volume of the gas decreases.
C. The gas particles collide less often.
D. The pressure of the gas decreases.

9. What relationship between the volume and pressure of a gas does this illustrate?
A. As volume decreases, pressure decreases.
B. As volume decreases, pressure increases.
C. As volume decreases, pressure remains the same.
D. As the volume increases, pressure remains the same.

Part 2 Short Response

10. The helium will expand to occupy the volume and shape of the room.

11. The pressure she exerts is 1.52 N/cm^2 on the left and 13 N/cm^2 on the right.

12. Large clown shoes would increase the area over which she exerts force, so the force would be divided by a larger area, which would mean the pressure she exerted would be less.

13. The gas in the balloon will expand. As the temperature is increased, the particles of air in the balloon have more kinetic energy. They collide with one another more frequently and increase the pressure on the inside of the balloon.

14. Thermal energy is the total kinetic energy of all the particles in a sample of matter. Heat is the movement of thermal energy from a substance of higher energy to one of lower energy.

15. Attractive forces cause the particles on the surface of a liquid to pull themselves together and resist being pushed apart. This surface tension causes the water to act as if a thin film were stretched across it surface. The insects are able to move around on this "film."

16. The upward buoyant force is equal to the downward force of the object's weight.

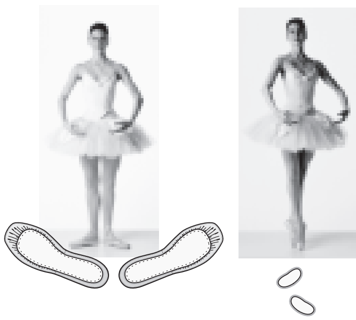
17. 12 g

Part 2 Short Response/Grid In

Record your answers on the answer sheet provided by your teacher or on a sheet of paper.

10. A balloon filled with helium bursts in a closed room. What space will the helium occupy?

Use the illustration below to answer questions 11 and 12.



11. If the force exerted by the dancer is 510 N, what is the pressure she exerts if the area is 335 cm^2 on the left and 37 cm^2 on the right?

12. Compare the pressure the dancer would exert on the floor if she were wearing large clown shoes to the photo on the left.

13. If a balloon is blown up and tied closed, air is held inside it. What will happen to the balloon if it is then pushed into hot water or held over a heater? Why does this happen?

14. What is the relationship of heat and thermal energy?

15. Why are some insects able to move around on the surface of a lake or pond?

16. How does the weight of a floating object compare with the buoyant force acting on the object?

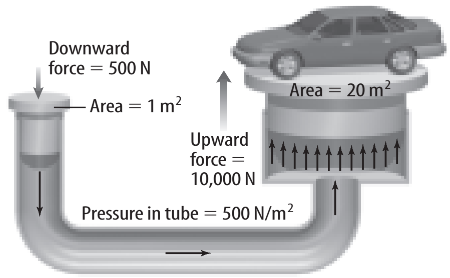
17. What is the mass of an object that has a density of 0.23 g/cm^3 and whose volume is 52 cm^3?

Part 3 Open Ended

Record your answer on a sheet of paper.

18. Compare and contrast evaporation and boiling.

Use the illustration below to answer questions 19 and 20.



19. Name and explain the principle that is used in lifting the car.

20. Explain what would happen if you doubled the area of the piston on the right side of the hydraulic system.

21. Explain why a woman might put dents in a wood floor when walking across it in high-heeled shoes, but not when wearing flat sandals.

22. Explain why the tires on a car might become flattened on the bottom after sitting outside in very cold weather.

23. Compare the arrangement and movement of the particles in a solid, a liquid, and a gas.

24. Explain why the water in a lake is much cooler than the sand on the beach around it on a sunny summer day.

Test-Taking Tip

Show Your Work For open-ended questions, show all of your work and any calculations on your answer sheet.

Hint: In question 20, the pressure in the tube does not change.

21. High-heeled shoes have a smaller area than sandals do. The force the woman exerts on the floor would be greater when she is wearing high-heeled shoes than when she is wearing sandals. This greater force might be enough to put dents in the wood floor.

22. When the temperature of a confined gas decreases, the speed of the gas particles slow down and the less kinetic energy they have. The particles collide less, so they exert less pressure on the inside of the tire making the tire look flat instead of round.

23. Solid particles are very close together and vibrate in place. Liquid particles move more freely than solid particles and have enough energy to move from their fixed positions. Gas particles are much further apart than solid or liquid particles and spread out evenly as far apart as possible.

24. Water has a higher specific heat than sand does. It takes a much larger quantity of heat to make the temperature of the water rise as much as the sand. So the water heats up more slowly than the sand.

Rubrics

For more help evaluating open-ended assessment questions, see the rubric on p. 10T.

Part 3 Open Ended

18. Both are forms of vaporization where a liquid changes to a gas. Evaporation is vaporization that takes place at the surface of a liquid and occurs at temperatures below the boiling point. Boiling is vaporization that takes place below the surface of a liquid. During boiling, bubbles form within the liquid and rise to the surface. Boiling takes place at a particular temperature called the boiling point of the liquid.

19. Pascal's principle is used in lifting the car. Pascal's principle says that when a force is applied to a confined fluid, an increase in pressure is transmitted equally to all parts of the fluid.

20. By doubling the area of the piston on the right side, the force exerted on the piston would also be doubled. This is because the pressure on the piston would still be 500 N/m^2, but the piston would have an area of 40 m^2. This means the force on the piston would be 500 N/m^2 $\times$ 40 m^2 or 20,000 N.