Category IV Physical Science Examples

Representing ideas effectively

Material B
Many of the drawings of molecules included in the student text are hard to interpret and misleading. For example, one drawing shows air containing molecules (rather than consisting of molecules) (p. **66s**). Several drawings show molecules of solids, liquids, and gases with different colors, which could be interpreted as representing a change in the type of molecules (see, for example, pp. **67s** and **74s**).

Apply

ACTIVITY
DISCOVERING

Determining Particle Space

Skill: Making observations

Materials: 250-mL beaker, marbles, sand, water

In this activity students will notice that there is space between the particles in a solid and in a liquid. Students will observe that the marbles do not fill all the available space in the beaker. Sand can be added, which will fill the spaces between the marbles. The amount of water that can be added will vary, but students should note that the water can also fill some of the space between the particles of sand and the marbles.

Rain disappears into the spaces between the particles of dirt in the lawn.

Develop

▶ Point out that when the particles of a gas collide, the pressure increases, causing more and more collisions. Point out that anything that increases the number of particle collisions within a gas will increase the pressure. Tell students to imagine two streets: One street is crowded with many cars; the other street has only two cars.

- **On which street do you predict it is more likely to have a collision? Why?** (The street crowded with cars. The cars have less room to move.)
- **Picture a jar full of gas particles. What will happen to the number of collisions if the container becomes smaller? Why?** (It will increase. Each particle has less space in which to move because the particles are closer to one another and to the sides of the container.)
- **Suppose the jar becomes larger. What will happen to the number of collisions? Why?** (It will decrease. Each particle has more space in which to move.)

▶ Write on the chalkboard:
Volume up ↑, pressure down ↓.
Volume down ↓, pressure up ↑.

Point out that this relationship between volume and pressure is called *Boyle's law.* Explain that Boyle's law states that the volume of a fixed amount of gas varies inversely with the pressure exerted on it, provided the temperature remains constant.

Then tell students that when pressure is held constant, the volume of a gas increases as temperature increases and decreases as temperature decreases. This is *Charles's law.* Stress that this temperature-volume relationship assumes that the pressure remains constant.

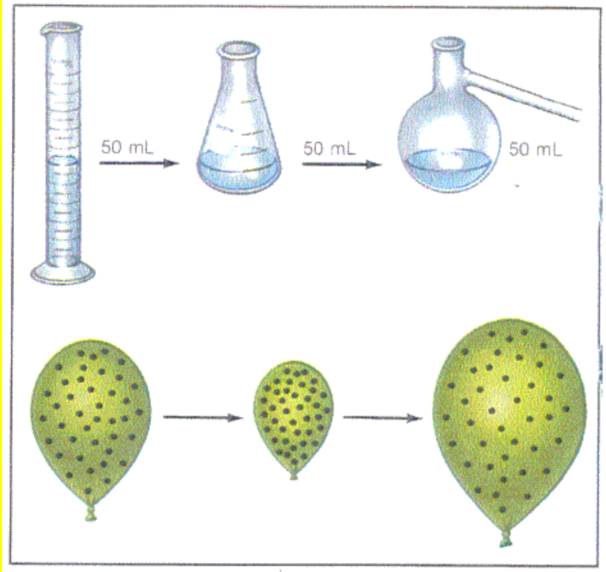


Figure 3–8 *A liquid has a definite volume but not a definite shape. It takes the shape of its container. An identical volume of liquid in three differently shaped glass vessels has three different shapes. A gas has neither a definite volume nor a definite shape. How would you describe the volume of a gas?* ❶

ACTIVITY
DISCOVERING

Determining Particle Space

1. Fill one 250-mL beaker with marbles, another with sand, and a third with water.

2. Describe the appearance of the beaker filled with marbles. Do the marbles occupy all the space in the beaker? Can you fit more marbles in the beaker?

3. Carefully pour some sand from its beaker into the beaker of marbles. How much sand are you able to pour? Is all the space in the beaker now occupied by marbles and sand?

4. Carefully add some water from its beaker to the beaker of marbles and sand. How much water can you add?

Is there space between the particles of a solid or a liquid?

■ How does what you observed partially explain the disappearance of rain on a lawn?

The behavior of gases can be explained in terms of the arrangement and movement of their particles. The world inside a container of gas particles is not as quiet as it may seem. Although you cannot see the particles of gas, they are in constant motion—moving about freely at speeds of nearly 100 meters per second. Whizzing around at such great speeds, the particles are constantly hitting one another. In fact, a single particle undergoes about 10 billion collisions per second! The particles are also colliding with the walls of the container. The effect of all these collisions is an outward pressure, or push, exerted by the gas. This pressure is what makes the gas expand to fill its container. What do you think would happen if the pressure in the container became too great? ❷

BOYLE'S LAW Imagine you are holding an inflated balloon. If you press lightly on the outside of the balloon, you can feel the air inside pushing back. Now if you squeeze part of the balloon, what do you feel? You probably feel the air pressing against the wall of the balloon with even greater force.

This increase in pressure is due to a decrease in volume. By squeezing the balloon, you reduce the

TEACHING SUPPORT

ANNOTATION KEY

Answers

❶ Gases have no definite volume. They always fill their container regardless of its size and shape. (Applying concepts)

❷ The container breaks or explodes. (Making predictions)

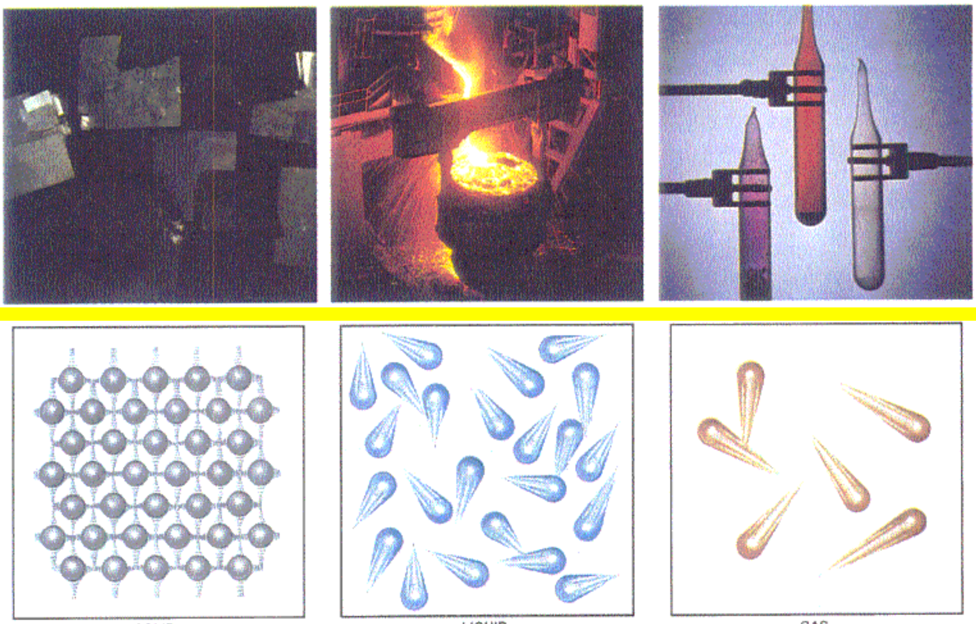
Integration

❶ Mathematics

space the gas particles can occupy. As the particles are pushed a bit closer together, they collide with one another and with the walls of the balloon even more. So the pressure from the moving gas particles increases. The relationship between volume and pressure is explained by Boyle's law. According to 1 Boyle's law, the volume of a fixed amount of gas varies inversely with the pressure of the gas. In other words, as one increases, the other decreases. If the volume of a gas decreases, its pressure increases. If the volume increases, its pressure decreases.

CHARLES'S LAW Imagine that you still have that inflated balloon. This time you heat it very gently. What do you think happens to the volume of gas inside the balloon? As the temperature increases, the gas particles absorb more heat energy. They speed up and move farther away from one another. So the increase in temperature causes an increase in volume. If the temperature had decreased, the volume would have decreased. This relationship between temperature and volume is described by Charles's law. According to Charles's law, the volume of a

Figure 3–9 *In a solid, such as these crystals of iron pyrite, or fool's gold (top left), the particles are packed closely together and cannot move far out of place. In a liquid, such as molten iron (top center), the particles are close together but are free to move about or flow. In a gas, such as iodine, bromine, and chlorine (top right), the particles are free to spread out and fill the available volume.*



BACKGROUND INFORMATION

Kinetic Energy

Because the particles of a gas are in constant motion, they have kinetic energy. Increasing the temperature of a gas makes the particles move faster, thus increasing their kinetic energy. Collisions also increase kinetic energy as faster-moving, high-energy particles transfer energy to slower-moving particles.

INTEGRATION

Mathematics

Boyle's law and Charles's law can be represented by proportions. Boyle's law (an inverse proportion) can be stated

$$P_1V_1 = P_2V_2$$

or

$$P_1/P_2 = V_2/V_1$$

Charles's law (a direct proportion) can be stated

$$T_1V_2 = T_2V_1$$

or

$$T_1/T_2 = V_1/V_2$$

Practice

Check for student understanding with the following:

▶ Activity

Have students determine which of the following statements represent an inverse relationship and which represent a direct relationship:

The greater the number of hours worked, the more money earned. (Direct.)

The greater a car's speed, the farther it travels in one hour. (Direct.)

The more hours you sleep in a day, the fewer hours you are awake. (Inverse.)

The greater the number of cars on the road, the greater the chances of an accident. (Direct.)

The more people who enter a contest, the less chance I have of winning. (Inverse.)

Develop

▶ ESL Strategy Remind students that Boyle's law and Charles's law both refer to a fixed amount of gas and its volume. Have them demonstrate their understanding of these laws by completing the blanks in the following sentences. You may want to write the sentences on the chalkboard and ask for volunteers to complete them. Have students read the completed sentences aloud.

Boyle's Law

With a fixed amount of gas, when the ______ is increased, the volume ______. When the ______ is decreased, the volume ______. (Pressure, decreases, pressure, increases.)

Charles's Law

With a fixed amount of gas, when the ______ is increased, the volume ______. When the ______ is decreased, the volume ______. (Temperature, increases, temperature, decreases.)

Apply

PROBLEM Solving

It's Only a Passing Phase

This feature should help students understand the function of heat energy during and between phase changes. The sloping segments of the graph indicate that between phase changes, the addition of heat energy causes an increase in temperature and the removal of heat energy causes a decrease in temperature. During phase changes the heat energy functions differently. The addition of energy to the individual particles enables them to move faster, thus converting a solid structure into a liquid structure or a liquid into a gas. Conversely, the removal of energy from the individual particles slows them down, converting a gas into a liquid or a liquid into a solid. There is no change of temperature during the phase change.

Integration: Use the Problem Solving feature to integrate mathematics concepts into your lesson.

Solid-Gas Phase Changes

Develop

▶ Tell students that some solids do not pass through the liquid phase and then into the gas phase. Certain solids pass directly from a solid phase into a gas phase by a process called *sublimation.*

Practice

Check for student understanding with the following:

Teaching Resources

▶ **Activity** Students who need practice on changes of phase should complete the Chapter 3 Activity Phase Changes on p. 17 in the *Teaching Resources.*

4 CLOSE

Review and Reinforce

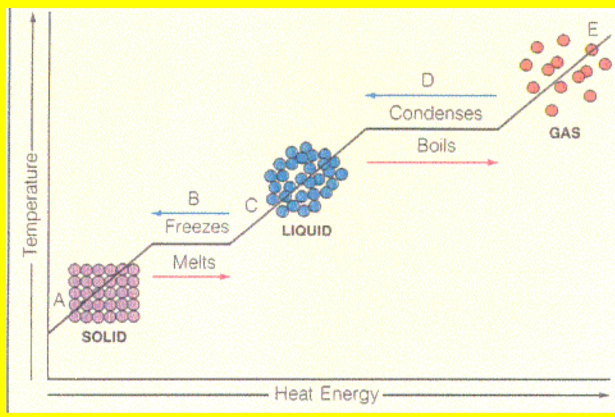
Teaching Resources Have students complete the Review and Reinforcement for Section 3–2 on p. 19.

PROBLEM Solving

It's Only a Passing Phase

Heat plays an important role in phase changes. Heat is energy that causes particles of matter to move faster and farther apart. As particles move faster, they leave one phase and enter another. Phase changes produce changes in only the physical properties of matter. They do not produce changes in the chemical properties. A substance is still the same kind of matter regardless of its phase.

The accompanying diagram is called a phase-change diagram. It shows the heat energy-temperature relationships as an ice cube becomes steam. Study the diagram and then answer the following questions.



Interpreting Diagrams

1. At which points does the addition of heat energy cause an increase in temperature?
2. At which points is there no temperature change despite the addition of heat energy?
3. What is happening at these points? ❶
4. What is happening to the heat energy at the points where there is no temperature drop?
5. How can you apply this information to activities and/or occurrences in your daily life?

Solid-Gas Phase Changes

If you live in an area where winters are cold, you may have noticed something unusual about fallen snow. Even when the temperature stays below the melting point of the water that makes up the snow, the fallen snow slowly disappears. What happens to it? The snow undergoes **sublimation** (suhb-luh-MAY-shuhn). When a solid sublimes, its surface particles escape directly into the gas phase. They do not pass through the liquid phase.

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Assess

3–2 Section Review Answers

1. By adding or removing heat energy.
2. Melting point: temperature at which a solid changes into a liquid; freezing point: temperature at which a liquid changes into a solid.
3. Evaporation: liquid-to-gas change at surface of liquid; condensation: gas-to-liquid change.
4. As dry ice sublimes, it absorbs heat energy, and its surface particles escape directly into the gas phase.
5. Over time, the ice cubes melt, the temperature of the water in the glass decreases, and the level of the water in the glass goes up.