Questions

particles of water acquire enough kinetic energy to overcome the attractive forces that hold molecules close enough together to maintain a liquid state. Under normal conditions, individual particles randomly escape from the surface of the liquid to become gas. How easy it is for these particles to change from a liquid to a gas depends upon the overall size and composition of the individual particles as well as the temperature of the liquid. In this experiment, the green food coloring will not evaporate with the water because the particles that compose the green food coloring are much larger and were dissolved in the water. Thus these particles remain as a solid after the water evaporates.

The Balloon

Upon heating, most of the molecules found in air acquire more kinetic energy and begin to move more rapidly. This results in molecules hitting the sides of the balloon more often and with greater impact. Due to the elastic nature of the balloon, these collisions cause the volume of the balloon to increase. When the students try to explain this activity in terms of the particle theory of matter, you might discover they hold the common misconception that the individual particles are getting larger as they get hotter.

Red Streamers

This activity illustrates the influence temperature has on the molecular motion of material. Molecules in cool liquid materials have less kinetic energy so they move around less rapidly than those in warm liquid materials. The addition of the red food coloring provides marked molecules so students can follow the motion of the water molecules. When you add the food coloring to the hot water, the rapidly moving water particles collide often and vigorously with the particles of food coloring. Thus the particles of food coloring rapidly diffuse throughout the hot water in the beaker. In the cold water, however, the interaction between the water particles and the particles of food coloring is less energetic, so the food coloring drifts downward through the water and diffuses more slowly.

The Amazing Coin Dancers

The behavior of air molecules inside the bottle is identical to that of air molecules in the balloon experiment above. Again, the motion of the particles that compose the air in the bottle are responding to the change in bottle temperature. Upon cooling, air particles move more slowly and, hence, bounce around less. When you place the bottle in the warm water, the air molecules inside the bottle respond by moving faster and bouncing around more. This increases the frequency and impact of molecules hitting the coin enough that the particles push the coin up every so often.

Rainmakers

This activity illustrates both the evaporation and condensation processes. Water particles in the bottom of the flask acquire enough energy to change from liquid to vapor. In the gas phase, the water particles rapidly move about, filling the entire beaker above the liquid. Some of these water particles strike the surface of the flask and lose energy as they cool off. If enough energy is transferred away from the water molecule, that molecule's kinetic energy can decrease so that other, less energetic molecules will coalesce together and form liquid water. When enough water molecules collect so that the resulting drop is too heavy to remain attached to the glass of the flask, you can observe a drop falling down to the bottom of the beaker.

Scientific Models

Scientists construct theories to explain observations of the natural world. The elements that make up theories often are unobservable themselves, but scientists base them on inferences they have derived from observations. For example, it is

understand, however, that when they put their balloons in this incubator, neither they nor the balloon should touch the light bulb.

- A floodlight.

You might want to practice tying filled balloons because many of the students will ask for your help in this. If you cannot obtain the materials in large enough quantities for the students to work individually, structure the activity for cooperative teams of three.

Materials

1 hot plate
1 heat-proof glass beaker or container, 250-mL
ice waste bowl and pitcher of cold tap water (optional if you do not have a sink)
cold water
hot water (optional)
heat source (as described in the Advance Preparation)
30 balloons, 10-in. round
10 to 30 large bowls of crushed ice
30 metric tape measures
60 glass beakers, 600-mL
1 bottle green food coloring
10 bottles red food coloring
30 medicine droppers
10 to 30 hot pads
1 ball of string (optional)

Cautions

Before you proceed with this investigation, share the following cautions with your students:

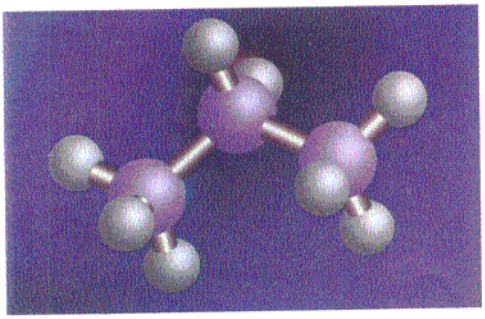
- Working with glass always carries the risk of injury if you drop or break a fixture.
- When working with water, wipe up any spills on the floor immediately to avoid possible accidents.
- Handle beakers of hot water only with hot pads.
- Take care when disposing of hot water not to splash yourself or those around you.
- Do not chew on balloons or parts of broken balloons.

Strategies

Getting Started

Have the students work on this investigation individually. The purpose of this investigation is to let the students elaborate and apply their knowledge of the particle theory of matter and to try to use a scientific model to explain their own observations. The model they are using is, at best, incomplete, so they likely will struggle somewhat in developing explanations. In addition not all students will be convinced that everything,

▶ FIGURE 10.6
A molecular model such as this one shows the arrangement of specific atoms within the molecule. This is a model of a propane molecule.



Working Cooperatively
You will work individually in this investigation at your desk or at a lab station.

Materials for Each Student:

Part B—The Balloon
- 1 balloon
- 1 heat source
- 1 large bowl of crushed ice and water
- 1 metric measuring tape

Part C—Red Streamers
- 2 glass beakers, 600-mL
- crushed ice
- cold water
- red food coloring
- hot water
- 1 medicine dropper
- 2 hot pads

Process and Procedure

Part A—Houdini Water

1. Observe the experimental setup that your teacher has assembled.
2. Predict what you think will happen in this experiment.
   Notebook entry: Record your predictions.
3. Observe what happens in the experiment.
   Notebook entry: Record your observations.
4. Participate in the class discussion about the experiment.
   Be prepared to share your ideas with the rest of the class.