Chapter

9

The Gas State

In this chapter, you will be able to

- explain different states of matter in terms of the forces among atoms, molecules, and ions;
- use the kinetic molecular theory to describe and explain the behaviour of gases;
- determine through experimentation the algebraic and graphical relationships among the pressure, volume, and temperature of an ideal gas;
- describe the mathematical relationships among the pressure, volume, temperature, and amount of an ideal gas;
- solve quantitative problems involving laws that describe the properties and behaviour of gases;
- use the terms standard temperature and pressure (including STP and SATP), absolute or Kelvin temperature, and ideal gas;
- convert between various units of pressure and between Celsius and Kelvin temperatures;
- describe various natural events and technological products and processes associated with gases;
- identify technological uses and safety concerns of compressed gases;
- identify the components of the atmosphere and describe Canadian initiatives to improve air quality.

The photograph in **Figure 1** is a dramatic depiction of how a gas can save a human life. In a car crash, an air bag, especially in combination with a seat belt, can protect the driver from serious injury. Upon collision, sensors in the steering column and in the bumper initiate the decomposition of sodium azide into sodium metal and nitrogen gas. This reaction is extremely fast: Nitrogen gas is produced and expands into the bag in less than 0.04 s. After cushioning the impact, the air bag gradually deflates as the nitrogen gas escapes through the permeable bag. Instead of taking a trip to the hospital, the driver takes a trip to the automobile body shop to have the air bag mechanism recharged and the triggering devices reset.

Air bags are not the only use of gases in the operation of automobiles: Tires and shock absorbers are inflated with pressurized air to provide a safe and comfortable ride. Air enters through the car's vents and is cooled by the air conditioner to keep us comfortable on hot summer days or is heated by the car engine to keep us warm in winter. Inside the combustion cylinders of the engine, a gasoline and oxygen explosion produces a large amount of gas at high temperature, which moves a piston. This is an example of converting chemical energy into motion. Finally, the gases emitted by automobile exhausts, such as carbon oxides and nitrogen oxides, diffuse into the atmosphere as pollutants.

As you can see, gases play an important role in both technology and our natural environment. In this chapter, you will learn more about the properties and uses of gases.

Reflect on your Learning

1. Since many gases are invisible, how do you think we can study them?
2. All around us, we see examples of all three states of matter. Why are some substances solid, liquid, or gas? How is this explained by the forces between the molecules?
3. Weather reports often refer to low- and high-pressure systems. What does pressure of a gas mean?
4. What determines the quality of the air in our atmosphere?

Throughout this chapter, note any changes in your ideas as you learn new concepts and develop your skills.

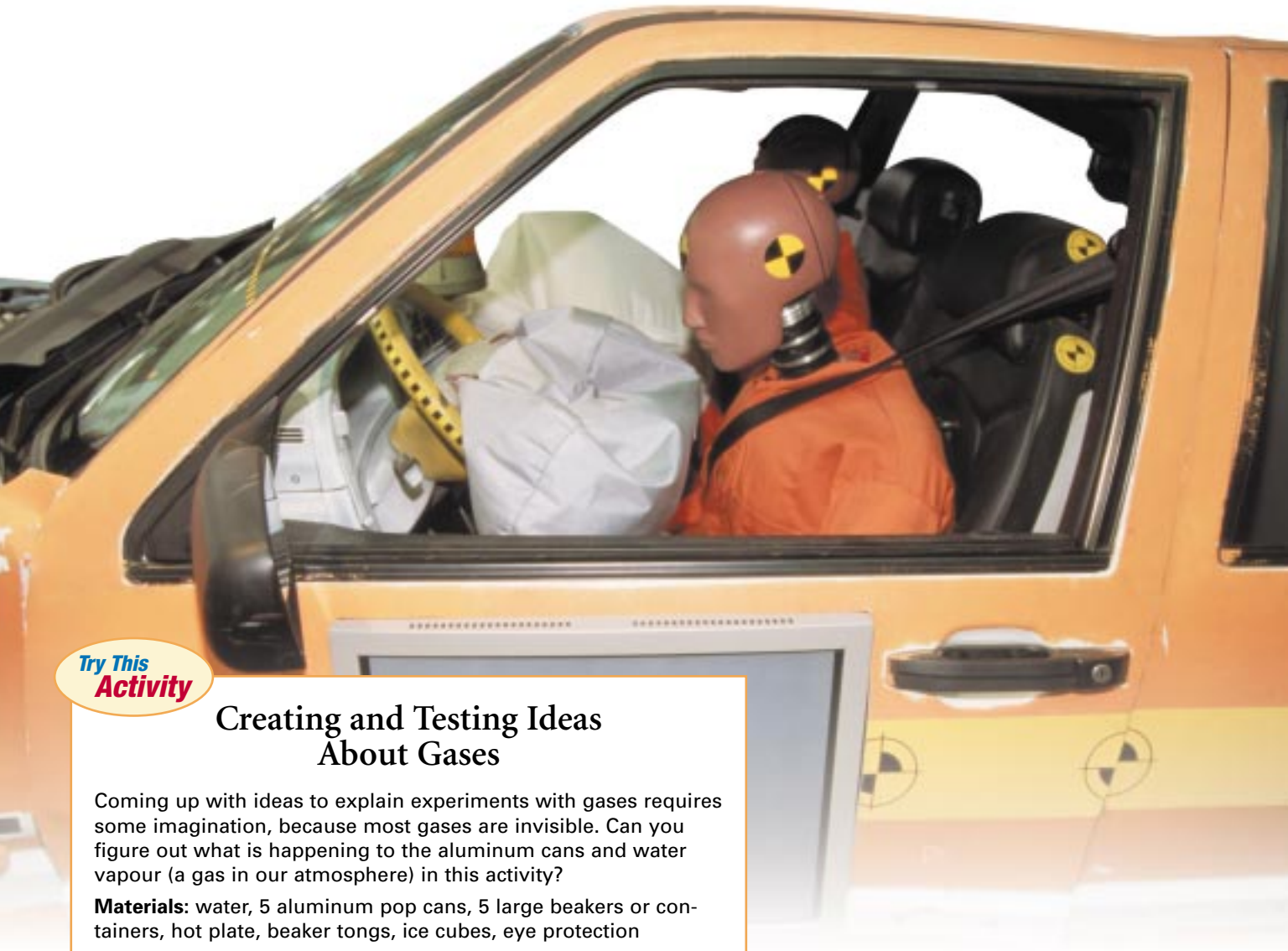

Figure 1
Air bags are a good example of how knowledge of gas reactions and gas properties can be used in life-saving technology.

Try This Activity

Creating and Testing Ideas About Gases

Coming up with ideas to explain experiments with gases requires some imagination, because most gases are invisible. Can you figure out what is happening to the aluminum cans and water vapour (a gas in our atmosphere) in this activity?

Materials: water, 5 aluminum pop cans, 5 large beakers or containers, hot plate, beaker tongs, ice cubes, eye protection

Care is required handling hot items. Steam can scald skin. Switch off hot plate immediately after use.

- Place about 20 mL of water in an empty aluminum pop can.
- Heat the can on a hot plate until steam rises steadily out of the top for a couple of minutes.
- Fill a large beaker to near the top with cold water.
- Using the tongs, lift the can and move it quickly to the beaker of cold water.
- Invert the can, and dip the top rim of the can just under the surface of the water.
- Record your observations.

(a) Create a Hypothesis for what happens.

- Repeat the Procedure without placing any water in the can. (Heat the can for a few minutes.)

(b) What happens now? Does this support or refute your Hypothesis?
(c) Using your original or revised Hypothesis, predict the results if you repeat the Procedure inverting the steaming can into ice water and warm water.
(d) Try each of these, then judge your Prediction and Hypothesis.

- Recycle the cans.