Chapter

10

Gas Mixtures and Reactions

In this chapter, you will be able to

- describe the total pressure of a gas mixture as the sum of the partial pressures;
- state natural and technological examples in which partial pressure plays a role;
- explain Dalton's law of partial pressures using the kinetic molecular theory;
- use the law of combining volumes to solve for reacting volumes of gases;
- state Avogadro's theory and describe its importance in understanding gas reactions;
- define and use molar volumes at STP and SATP to convert between volumes and amounts of gases;
- determine, experimentally, the molar volume of a gas;
- perform stoichiometric calculations for reactions involving gases;
- describe how knowledge of gases relates to natural phenomena, technological products, and other areas of study.

Seen from space, our atmosphere does not look very impressive—only a thin blue layer around the planet—yet it is essential to our existence (**Figure 1**). A complex, variable mixture of gases, it is also the medium for a great variety of both useful and harmful gas reactions. Many familiar gases in the atmosphere have a dual personality: Oxygen gas is essential for us to breathe, but too little or too much is deadly. Nitrogen is an important nutrient source for plants (and indirectly for us), but its reactions with oxygen can produce dangerous substances such as those found in smog and acid rain. Carbon dioxide is necessary for green plants to produce food and oxygen by photosynthesis, but too much may have long-term, undesirable climate effects or can be suffocating (**Figure 2**). Ozone is another good example of an atmospheric gas that is both useful and dangerous. High in the atmosphere, a low-density ozone layer protects us from harmful UV radiation, but in the lower atmosphere ozone is a very destructive and lethal chemical.

These gases are only some of the constituents of the atmosphere. There are many others that are formed by natural or technological processes. An understanding of the properties of gas mixtures and reactions is necessary to begin to understand the complex atmosphere in which we live.

Reflect on your Learning

The concentrations of the gases in our atmosphere change with time. Sometimes these changes are local; sometimes they are global. Sometimes the concentrations vary as a result of natural causes, such as a volcano, and sometimes they are due to activities by humans, such as our production of car exhaust pollution.

1. How do the properties of gas mixtures, like the atmosphere, compare with those of other homogeneous mixtures, such as aqueous solutions?
2. How is the study of the reactions of gases similar to and different from other reactions you have studied?
3. What are some beneficial applications of gases and some problems associated with gases?

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

Figure 2
The release of carbon dioxide from underground gas pockets and the decomposition of limestone around Horseshoe Lake in California produces about 50 t to 150 t of carbon dioxide per day. This has killed many trees, particularly at the north end of the lake; it can also easily asphyxiate people and animals.

Try This **Activity**

Producing a "Natural" Gas

If you do this activity at home and do not have baking powder, you can use Alka-Seltzer tablets with tap water or baking soda (with some diluted 5% V/V vinegar instead of tap water).

Materials: a clear drinking glass, water, measuring spoon, baking powder, piece of cardboard to cover the glass, matches

- Fill the glass about two-thirds full with tap water.
- Add 10 mL (around 2 level teaspoons) of baking powder to the water and cover the glass with a piece of cardboard.
- Record your observations, noting in particular the activity above the surface of the liquid.
- When the reaction subsides, light a match, lift the cardboard momentarily, and insert the lit match into the top of the glass. Remove the match and replace the cardboard. Record your observations.
- Repeat the reaction. Light another match, remove the paper, and gently "pour" the gas in the glass over the lit match. Record your observations.
- Dispose of the liquid down the sink. Ensure the used matches are extinguished by dipping them in water before disposal in the regular garbage.

(a) What gases are present in the glass before adding the baking powder?
(b) What gas is present after the reaction? How do you know?
(c) What additional test could be done to test your answer to (b)?
(d) The gas produced in this reaction can be poured out of a glass. What does this suggest about the properties of this gas?
(e) What is a common technological application of this gas?
(f) What natural occurrence mentioned earlier exhibits the same physical events you observed above the liquid during the reaction?

Figure 1
Compared to the size of Earth, the height of the atmosphere is really very small. If Earth were an apple, the thickness of the atmosphere would be about one-half the thickness of the apple's skin.