SECTION 3

Limiting Reactants and Percentage Yield

OBJECTIVES

- Describe a method for determining which of two reactants is a limiting reactant.
- Calculate the amount in moles or mass in grams of a product, given the amounts in moles or masses in grams of two reactants, one of which is in excess.
- Distinguish between theoretical yield, actual yield, and percentage yield.
- Calculate percentage yield, given the actual yield and quantity of a reactant.

In the laboratory, a reaction is rarely carried out with exactly the required amount of each of the reactants. In many cases, one or more reactants is present in excess; that is, there is more than the exact amount required to react.

Once one of the reactants is used up, no more product can be formed. The substance that is completely used up first in a reaction is called the limiting reactant. *The* **limiting reactant** *is the reactant that limits the amount of the other reactant that can combine and the amount of product that can form in a chemical reaction. The substance that is not used up completely in a reaction is called the* **excess reactant.** A limiting reactant may also be referred to as a *limiting reagent.*

The concept of the limiting reactant is analogous to the relationship between the number of people who want to take a certain airplane flight and the number of seats available in the airplane. If 400 people want to travel on the flight and only 350 seats are available, then only 350 people can go on the flight. The number of seats on the airplane limits the number of people who can travel. There are 50 people in excess.

The same reasoning can be applied to chemical reactions. Consider the reaction between carbon and oxygen to form carbon dioxide.

$$C(s) + O_2(g) \longrightarrow CO_2(g)$$

According to the equation, one mole of carbon reacts with one mole of oxygen to form one mole of carbon dioxide. Suppose you could mix 5 mol C with 10 mol O_2 and allow the reaction to take place. **Figure 5** shows that there is more oxygen than is needed to react with the carbon. Carbon is the limiting reactant in this situation, and it limits the amount of CO_2 that is formed. Oxygen is the excess reactant, and 5 mol O_2 will be left over at the end of the reaction.

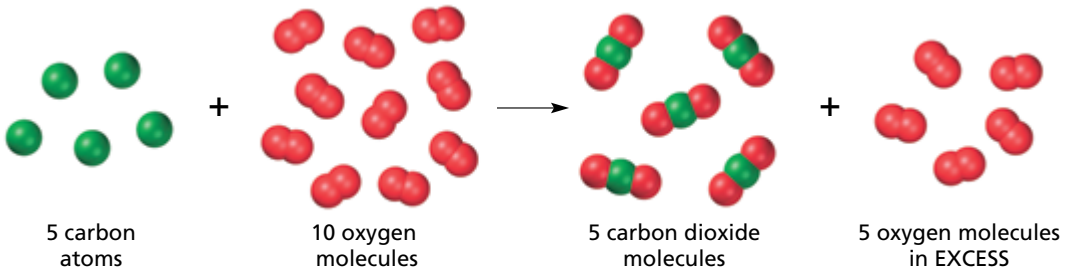

FIGURE 5 If you think of a mole as a multiple of molecules and atoms, you can see why the amount of O_2 is in excess.