$$\text{For N:} \quad \frac{2 \text{ moles N atoms}}{1 \text{ mole } N_2O_4 \text{ molecules}} \quad \text{or} \quad \frac{1 \text{ mole } N_2O_4 \text{ molecules}}{2 \text{ moles N atoms}}$$

$$\text{For O:} \quad \frac{4 \text{ moles O atoms}}{1 \text{ mole } N_2O_4 \text{ molecules}} \quad \text{or} \quad \frac{1 \text{ mole } N_2O_4 \text{ molecules}}{4 \text{ moles O atoms}}$$

Example 6.4 illustrates the use of this type of conversion factor in problem solving.

EXAMPLE 6.4
Calculating Molar Quantities of Compound Components

Lactic acid, the substance that builds up in muscles and causes them to hurt when they are worked hard, has the formula $C_3H_6O_3$. How many moles of carbon atoms, hydrogen atoms, and oxygen atoms are present in a 1.2-mole sample of lactic acid?

Solution

One mole of $C_3H_6O_3$ contains 3 moles of carbon atoms, 6 moles of hydrogen atoms, and 3 moles of oxygen atoms. We obtain the following conversion factors from this statement:

$$\left(\frac{3 \text{ moles C atoms}}{1 \text{ mole } C_3H_6O_3}\right) \quad \left(\frac{6 \text{ moles H atoms}}{1 \text{ mole } C_3H_6O_3}\right) \quad \left(\frac{3 \text{ moles O atoms}}{1 \text{ mole } C_3H_6O_3}\right)$$

Using the first conversion factor, we calculate the moles of carbon atoms present as follows:

$$1.2 \cancel{\text{ moles } C_3H_6O_3} \times \left(\frac{3 \text{ moles C atoms}}{1 \cancel{\text{ mole } C_3H_6O_3}}\right) = 3.6 \text{ moles C atoms}$$

Similarly, from the second and third conversion factors, the moles of hydrogen and oxygen atoms present are calculated as follows:

$$1.2 \cancel{\text{ moles } C_3H_6O_3} \times \left(\frac{6 \text{ moles H atoms}}{1 \cancel{\text{ mole } C_3H_6O_3}}\right) = 7.2 \text{ moles H atoms}$$

$$1.2 \cancel{\text{ moles } C_3H_6O_3} \times \left(\frac{3 \text{ moles O atoms}}{1 \cancel{\text{ mole } C_3H_6O_3}}\right) = 3.6 \text{ moles O atoms}$$

Practice Exercise 6.4

The compound deoxyribose, whose chemical formula is $C_5H_{10}O_4$, is an important component of DNA molecules, the molecules responsible for the transfer of genetic information from one generation to the next in living organisms. How many moles of carbon atoms, hydrogen atoms, and oxygen atoms are present in a 0.456-mole sample of deoxyribose?

Answers: 2.28 moles C atoms, 4.56 moles H atoms, and 1.82 moles O atoms

6.5 THE MOLE AND CHEMICAL CALCULATIONS

In this section, we will combine the things we have learned about moles to produce a general approach to problem solving that is applicable to a variety of chemical situations. In Section 6.2, we learned that *Avogadro's number* provides a relationship between the number of particles of a substance and the number of moles of that same substance:

$$\boxed{\text{Particles of Substance}} \xrightarrow[\text{involving Avogadro's number}]{\text{Conversion factor}} \boxed{\text{Moles of Substance}}$$

In Section 6.3, we learned that *molar mass* provides a relationship between the number of grams of a substance and the number of moles of that substance:

$$\boxed{\text{Grams of Substance}} \xrightarrow[\text{involving molar mass}]{\text{Conversion factor}} \boxed{\text{Moles of Substance}}$$

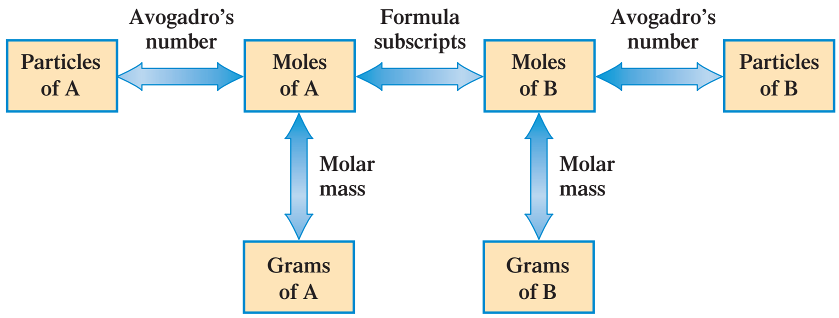

Figure 6.7 In solving chemical-formula-based problems, the only "transitions" allowed are those between quantities (boxes) connected by arrows. Associated with each arrow is the concept on which the required conversion factor is based.

In Section 6.4, we learned that the *molar interpretation of chemical formula subscripts* provides a relationship between the number of moles of a substance and the number of moles of its components:

$$\boxed{\text{Moles of Compound}} \xrightarrow[\text{chemical formula subscripts}]{\text{Conversion factor involving}} \boxed{\text{Moles of Element within Compound}}$$

The preceding three concepts can be combined into a single diagram that is very useful in problem solving. This diagram, Figure 6.7, can be viewed as a road map from which conversion factor sequences (pathways) may be obtained. It gives all the relationships we need for solving two general types of problems:

1. Calculations where information (moles, particles, or grams) is given about a particular substance, and additional information (moles, particles, or grams) is needed concerning the same substance.
2. Calculations where information (moles, particles, or grams) is given about a particular substance, and information is needed concerning a *component* of that same substance.

For the first type of problem, only the left side of Figure 6.7 (the "A" boxes) is needed. For problems of the second type, both sides of the diagram (both "A" and "B" boxes) are used.

The thinking pattern needed to use Figure 6.7 is very simple.

1. Determine which box in the diagram represents the *given* quantity in the problem.
2. Locate the box that represents the *desired* quantity.
3. Follow the indicated pathway that takes you from the given quantity to the desired quantity. This involves simply following the arrows. There will always be only one pathway possible for the needed transition.

Examples 6.5 and 6.6 illustrate two of the types of problems that can be solved by using the relationships shown in Figure 6.7.

Example 6.5
Calculating the Number of Particles in a Given Mass of Compound

Vitamin C has the formula $C_6H_8O_6$. Calculate the number of vitamin C molecules present in a 0.250-g tablet of pure vitamin C.

Solution

We will solve this problem by using the three steps of dimensional analysis (Section 2.8) and Figure 6.7.

Step 1: The given quantity is 0.250 g of $C_6H_8O_6$, and the desired quantity is molecules of $C_6H_8O_6$.

$$0.250 \text{ g } C_6H_8O_6 = ? \text{ molecules } C_6H_8O_6$$

In terms of Figure 6.7, this is a "grams of A" to "particles of A" problem. We are given grams of a substance, A, and desire to find molecules (particles) of that same substance.