Because of rounding or experimental error, a compound's mole ratio sometimes consists of numbers close to whole numbers instead of exact whole numbers. In this case, the differences from whole numbers may be ignored and the nearest whole number taken. Thus, diborane contains atoms in the ratio 1 B:3 H. The compound's empirical formula is BH_3.

Sometimes mass composition is known instead of percentage composition. To determine the empirical formula in this case, convert mass composition to composition in moles. Then calculate the smallest whole-number mole ratio of atoms. This process is shown in Sample Problem M.

SAMPLE PROBLEM L   *For more help, go to the Math Tutor at the end of Chapter 22.*

Quantitative analysis shows that a compound contains 32.38% sodium, 22.65% sulfur, and 44.99% oxygen. Find the empirical formula of this compound.

SOLUTION

1 ANALYZE   **Given:** percentage composition: 32.38% Na, 22.65% S, and 44.99% O
Unknown: empirical formula

2 PLAN   percentage composition $\longrightarrow$ mass composition $\longrightarrow$ composition in moles
$\longrightarrow$ smallest whole-number mole ratio of atoms

3 COMPUTE   Mass composition (mass of each element in 100.0 g sample): 32.38 g Na, 22.65 g S, 44.99 g O

Composition in moles: $32.38 \text{ g Na} \times \dfrac{1 \text{ mol Na}}{22.99 \text{ g Na}} = 1.408 \text{ mol Na}$

$22.65 \text{ g S} \times \dfrac{1 \text{ mol S}}{32.07 \text{ g S}} = 0.7063 \text{ mol S}$

$44.99 \text{ g O} \times \dfrac{1 \text{ mol O}}{16.00 \text{ g O}} = 2.812 \text{ mol O}$

Smallest whole-number mole ratio of atoms:
The compound contains atoms in the ratio 1.408 mol Na:0.7063 mol S:2.812 mol O. To find the smallest whole-number mole ratio, divide each value by the smallest number in the ratio.

$$\frac{1.408 \text{ mol Na}}{0.7063} : \frac{0.7063 \text{ mol S}}{0.7063} : \frac{2.812 \text{ mol O}}{0.7063} = 1.993 \text{ mol Na:1 mol S:3.981 mol O}$$

Rounding each number in the ratio to the nearest whole number yields a mole ratio of 2 mol Na:1 mol S:4 mol O. The empirical formula of the compound is Na_2SO_4.

4 EVALUATE   Calculating the percentage composition of the compound based on the empirical formula determined in the problem reveals a percentage composition of 32.37% Na, 22.58% S, and 45.05% O. These values agree reasonably well with the given percentage composition.