An empirical formula shows the simplest whole-number ratio among the elements in a compound. For example, the simplest ratio among the atoms in benzene, C_6H_6, can be expressed by the empirical formula CH (or C_1H_1). Empirical formulas may be calculated from simple analytical data, as shown in the example below.

Problem-Solving TIPS

- Sometimes, you can deduce the mole ratios of the elements in a compound just by examining the moles of each element. If not, divide the moles of each element by the moles of the least abundant element in the compound.

SAMPLE

Find the empirical formula of acetone, a common organic solvent, whose composition by mass is 62.04% carbon, 10.41% hydrogen, and 27.55% oxygen.

The easiest way to calculate an empirical formula from percentage composition is to consider a 100.00 g sample of the compound. In this case, a 100.00 g sample would contain 62.04 g of carbon, 10.41 g of hydrogen, and 27.55 g of oxygen. Convert each mass to moles so that you can compare the mole ratio of the three elements.

$$62.04 \text{ g C} \times \frac{1 \text{ mol C}}{12.01 \text{ g C}} = 5.166 \text{ mol C}$$

$$10.41 \text{ g H} \times \frac{1 \text{ mol H}}{1.008 \text{ g H}} = 10.33 \text{ mol H}$$

$$27.55 \text{ g O} \times \frac{1 \text{ mol O}}{16.00 \text{ g O}} = 1.722 \text{ mol O}$$

$$\frac{5.166 \text{ mol C}}{1.722} : \frac{10.33 \text{ mol H}}{1.722} : \frac{1.722 \text{ mol O}}{1.722}$$

$$3.000 \text{ mol C} : 5.999 \text{ mol H} : 1.000 \text{ mol O}$$

As you can see, the empirical formula of this compound is C_3H_6O.

PRACTICE PROBLEMS

1. Urea was the first organic compound to be synthesized in the laboratory. Urea's composition by mass is 20.00% carbon, 6.71% hydrogen, 46.65% nitrogen, and 26.64% oxygen. What is the empirical formula of urea?

2. An organic compound sometimes used in the manufacture of perfumes is 29.78% carbon, 4.17% hydrogen, and 66.05% bromine, by mass. What is the empirical formula of this compound?

3. The composition by mass of lactic acid is 40.00% carbon, 6.71% hydrogen, and 53.28% oxygen. What is the empirical formula of lactic acid?