# Formula Stoichiometry: Percentage Composition

1. What is the percent composition of $CO_2$?

$$M_{CO_2} = 44.01\,{}^{g}\!/\!_{mol}$$

$$\%C = \frac{12.01\text{ g C}}{44.01\text{ g CO}_2} \times 100 = 27.29\%C$$

$$\%O = 100 - 27.29 = 72.71\%O$$

-or-

$$\%O = \frac{2(16.00\text{ g O})}{44.01\text{ g CO}_2} \times 100 = 72.71\%O$$

2. What is the % composition of $(NH_4)_3PO_4$ (149.09 g/mol)?

   Just the %N calculation is shown here

$$\%N = \frac{3(14.007\text{ g N})}{149.09\text{ g (NH}_4)_3PO_4} \times 100 = 28.18\%N$$

3. By some means the percentage composition of a compound containing only Ti and O was determined to be 40.06% O and 59.94% Ti. What is the empirical formula of this compound?

   Start by assuming that there is 100g of $Ti_xO_y$. The mass doesn't matter; it's a convenience.

In 100 g of $Ti_xO_y$ :

$$m_{Ti} = 59.94\text{ g}$$

$$m_O = 40.06\text{ g}$$

$$n_{Ti} = {}^{59.94\text{ g Ti}}\!/\!_{47.88\,{}^{g}\!/\!_{mol}} = 1.252\text{ mol Ti}$$

$$n_O = {}^{40.06\text{ g O}}\!/\!_{16.00\,{}^{g}\!/\!_{mol}} = 2.504\text{ mol O}$$

Thus, formula is $Ti_{1.252}O_{2.504}$ and normalizing to whole numbers $TiO_2$

4. The percent composition of an ionic compound containing only Na, S, and O is 32.37% Na and 22.57% S. What is the empirical formula of the compound?

$$\%\text{O} = 100 - (32.37 + 22.57) = 45.06\%\text{O}$$

As in problem 3, assume 100 g of compound. Calculate moles of each element:

$$n_{\text{Na}} = 32.37 \text{ g Na} \Big/ 22.99 \tfrac{\text{g}}{\text{mol}} = 1.408 \text{ mol Na}$$

$$n_{\text{S}} = 22.57 \text{ g S} \Big/ 32.066 \tfrac{\text{g}}{\text{mol}} = 0.7039 \text{ mol S}$$

$$n_{\text{O}} = 45.06 \text{ g O} \Big/ 16.00 \tfrac{\text{g}}{\text{mol}} = 2.816 \text{ mol O}$$

Normalize to whole numbers by dividing by 0.7039:

$$n_{\text{Na}} = 2 \text{ mol Na}$$

$$n_{\text{S}} = 1 \text{ mol S}$$

$$n_{\text{O}} = 4 \text{ mol O}$$

Empirical Formula: $Na_2SO_4$

5. A compound containing only carbon, hydrogen, an oxygen was analyzed and found to be 40.00%C and 53.28%O. The molar mass of the compound was independently determined to be 180.2 g/mol. What is the molecular formula of the compound?

$$\%\text{H} = 100 - (40.00 + 53.28) = 6.72\%\text{O}$$

Assume 100 g of compound. Calculate moles of each element:

$$n_{\text{C}} = 40.00 \text{ g C} \Big/ 12.01 \tfrac{\text{g}}{\text{mol}} = 3.331 \text{ mol Na}$$

$$n_{\text{H}} = 6.72 \text{ g H} \Big/ 1.008 \tfrac{\text{g}}{\text{mol}} = 6.667 \text{ mol H}$$

$$n_{\text{O}} = 53.28 \text{ g O} \Big/ 16.00 \tfrac{\text{g}}{\text{mol}} = 3.330 \text{ mol O}$$

Normalize to whole numbers by dividing by 3.330:

$$n_{\text{C}} = 1 \text{ mol C}$$

$$n_{\text{S}} = 2 \text{ mol H}$$

$$n_{\text{O}} = 1 \text{ mol O}$$

Empirical Formula: $CH_2O$ with empirical molar mass of $30.03 \tfrac{\text{g}}{\text{mol}}$

Actual molar mass is $180.2 \tfrac{\text{g}}{\text{mol}}$

Ratio of molar mass to emp. molar mass $= \dfrac{180.2 \tfrac{\text{g}}{\text{mol}}}{30.03 \tfrac{\text{g}}{\text{mol}}} = 6.00$

Multiply each coefficient by 6: Molecular Formula: $C_6H_{12}O_6$