

Chemistry Lecture #58: Stoichiometric Mass-to-Mass Conversion

Stoichiometry is the calculation of relative quantities of reactants and products in chemical reactions. Stoichiometric calculations often try to determine how much product can be made from a given amount of reactant.

To illustrate the meaning of stoichiometry, suppose we have a formula for making a cake. The formula is



How many cakes can be made from 6 apples?



$$\frac{6 \text{ apples}}{1} \times \frac{1 \text{ cake}}{3 \text{ apples}} = 2 \text{ cakes}$$

Now instead of using a baking formula to calculate the number of cakes you can make, let's take a chemical reaction and calculate the amount of product you can make.



How many grams of Al_2O_3 can be made from 12.0 g of Al?

We'll use the following steps to solve mass-to-mass problems:

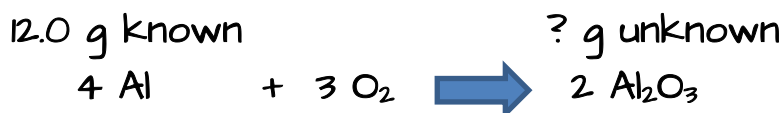
1. Identify the known and unknown compounds.
2. Find the molar mass of the known and unknown compounds.
3. Set up fractions, solve by factor-labeling

Memorize:

g known \rightarrow moles known \rightarrow moles unknown \rightarrow g unknown



How many grams of Al_2O_3 can be made from 12.0 g of Al?



$$1 \text{ mole Al} = 27.0 \text{ g}$$

$$1 \text{ mole Al}_2\text{O}_3 = 102 \text{ g}$$

g known \rightarrow moles known \rightarrow moles unknown \rightarrow g unknown

$$\frac{12.0 \text{ g Al}}{1} \times \frac{1 \text{ mole Al}}{27.0 \text{ g Al}} \times \frac{2 \text{ mole Al}_2\text{O}_3}{4 \text{ mole Al}} \times \frac{102 \text{ g Al}_2\text{O}_3}{1 \text{ mole Al}_2\text{O}_3} = 22.7 \text{ g Al}_2\text{O}_3$$

Thus, from 12.0 g of Al, we can obtain 22.7 g of Al_2O_3 .



How many grams of CrCl_3 are needed to make 0.840 g of MgCl_2 ?

Solution

Notice that this problem does not ask for the amount of product (MgCl_2); this is given to us. Instead, it asks for the amount of starting material, CrCl_3 . MgCl_2 is the known and CrCl_3 is the unknown.



$$\text{CrCl}_3 = 159 \text{ g/mole}$$

$$\text{MgCl}_2 = 95.3 \text{ g/mole}$$

g known \longrightarrow moles known \longrightarrow moles unknown \longrightarrow g unknown

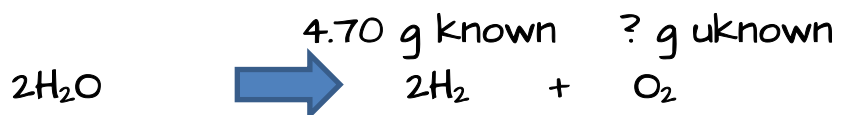
$$\begin{aligned} & \frac{0.840 \text{ g MgCl}_2}{1} \times \frac{1 \text{ mole MgCl}_2}{95.3 \text{ g MgCl}_2} \times \frac{2 \text{ mole CrCl}_3}{3 \text{ mole MgCl}_2} \times \frac{159 \text{ g CrCl}_3}{1 \text{ mole CrCl}_3} \\ & = 0.934 \text{ g CrCl}_3 \end{aligned}$$



A sample of H_2O is broken into its elements and yields 4.70 g of H_2 . How many grams of O_2 are also produced?

Solution

Notice that the known, H_2 and the unknown, O_2 , are both products. It is also possible to have problems where both the known and unknown are reactants.



$$\text{H}_2 = 2.02 \text{ g/mole}$$

$$\text{O}_2 = 32.0 \text{ g/mole}$$

g known \longrightarrow moles known \longrightarrow moles unknown \longrightarrow g unknown

$$\begin{aligned} \frac{4.70 \text{ g H}_2}{1} \times \frac{1 \text{ mole H}_2}{2.02 \text{ g H}_2} \times \frac{1 \text{ mole O}_2}{2 \text{ moles H}_2} \times \frac{32.0 \text{ g O}_2}{1 \text{ mole O}_2} \\ = 37.2 \text{ g O}_2 \end{aligned}$$