11.1.1: Mass Stoichiometry

Learning Objectives

- Convert from mass of one substance to mass of another substance in a chemical reaction.

Mass to Mass Stoichiometry Conversions

The first pathway we will look at is starting with grams of one chemical in an equation and ending with grams of another. See the highlighted portion below.

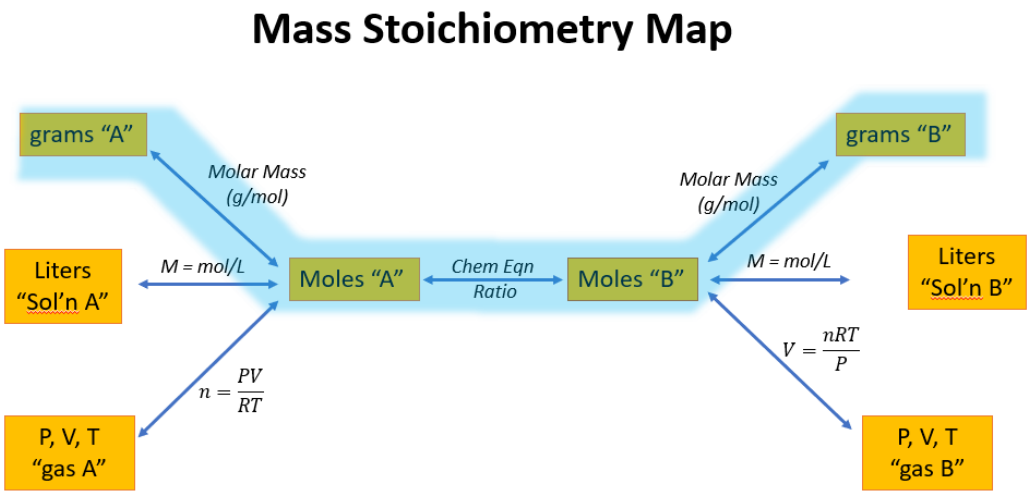


Figure 11.1.1.1: Mass stoichiometry pathway

Here's an example of how it will work.

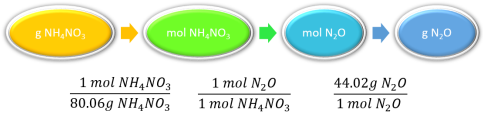
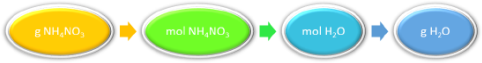
Example 11.1.1.2: Decomposition of Ammonium Nitrate

Ammonium nitrate decomposes to dinitrogen monoxide and water according to the following equation.

$$\mathrm{NH_4NO_3}\,(s) \rightarrow \mathrm{N_2O}\,(g) + 2\mathrm{H_2O}\,(l)$$

In a certain experiment, 45.7 g of ammonium nitrate is decomposed. Find the mass of each of the products formed.

Solutions to Example 8.5.2

Steps for Problem Solving	Example 11.1.1.2
Identify the "given" information and what the problem is asking you to "find."	Given: 45.7 g $\mathrm{NH_4NO_3}$ Find: Mass $\mathrm{N_2O}$ =? g Mass $\mathrm{H_2O}$ =? g
List other known quantities.	1 mol $\mathrm{NH_4NO_3}$ = 80.06 g/mol 1 mol $\mathrm{N_2O}$ = 44.02 g/mol 1 mol $\mathrm{H_2O}$ = 18.02 g/mol 1 mol NH_4NO_3 to 1 mol N_2O to 2 mol H_2O
Prepare two concept maps and use the proper conversion factor.	 $\frac{1\ mol\ NH_4NO_3}{80.06g\ NH_4NO_3}$ $\frac{1\ mol\ N_2O}{1\ mol\ NH_4NO_3}$ $\frac{44.02g\ N_2O}{1\ mol\ N_2O}$ Flowchart of conversion factors: 1 mole NH4NO3 to 80.06 grams NH4NO3, 1 mole N2O to 1 mole NH4NO3, 44.02 grams N2O to 1 mole N2O  $\frac{1\ mol\ NH_4NO_3}{80.06g\ NH_4NO_3}$ $\frac{2\ mol\ H_2O}{1\ mol\ NH_4NO_3}$ $\frac{18.02g\ H_2O}{1\ mol\ H_2O}$ Flowchart of conversion factors: 1 mole NH4NO3 to 80.06 grams NH4NO3, 2 moles H2O to 1 mole NH4NO3, 18.02 grams H2O to 1 mole H2O

Steps for Problem Solving	Example 11.1.1.2
Cancel units and calculate.	$45.7\ \text{g}\ \text{NH}_4\text{NO}_3 \times \frac{1\ \text{mol}\ \text{NH}_4\text{NO}_3}{80.06\ \text{g}\ \text{NH}_4\text{NO}_3} \times \frac{1\ \text{mol}\ \text{N}_2\text{O}}{1\ \text{mol}\ \text{NH}_4\text{NO}_3} \times \frac{44.02\ \text{g}\ \text{N}_2\text{O}}{1\ \text{mol}\ \text{N}_2\text{O}} = 25.1$ $45.7\ \text{g}\ \text{NH}_4\text{NO}_3 \times \frac{1\ \text{mol}\ \text{NH}_4\text{NO}_3}{80.06\ \text{g}\ \text{NH}_4\text{NO}_3} \times \frac{2\ \text{H}_2\text{O}}{1\ \text{mol}\ \text{NH}_4\text{NO}_3} \times \frac{18.02\ \text{g}\ \text{H}_2\text{O}}{1\ \text{mol}\ \text{H}_2\text{O}} = 20.6$
Think about your result.	The total mass of the two products is equal to the mass of ammonium nitrate which decomposed, demonstrating the law of conservation of mass. Each answer has three significant figures.

? Exercise 11.1.1.2: Carbon Tetrachloride

Methane can react with elemental chlorine to make carbon tetrachloride (CCl_4). The balanced chemical equation is as follows:

$$\text{CH}_4(\text{g}) + 4\,\text{Cl}_2(\text{g}) \rightarrow \text{CCl}_2(\text{l}) + 4\,\text{HCl}(\text{l})$$

How many grams of HCl are produced by the reaction of 100.0 g of CH_4?

Answer

908.7g HCl

Summary

- A balanced chemical reaction can be used to determine mass relationships between substances.
