Chapter 3
Stoichiometry - Introduction

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Stoichiometry

- **Stoichiometry** helps us to find out
  - How much starting material is required to produce a certain amount of product
  - The amount of product that can be produced from a certain amount of starting material.
  - How will the reaction be affected if there is more than one starting material (limiting reagent)?
  - Will there be any starting material left over?
  - How efficient is the process (% yield)?
- A **chemical reaction** is representation of chemicals in a reaction.
  - A reaction is written in chemical symbols so that it is clear how many atoms are being used.
  - A chemical reaction where reactants are written on the left and products on the right with an arrow (yield) to show progress of reaction.

$$\text{Reactants} \xrightarrow{\textit{yields}} \text{Products}$$

Stoichiometry – setting up

The calculation of the quantities of reactants and products involved in a chemical reaction.

Interpreting a Chemical Equation

The coefficients of the balanced chemical equation can be interpreted as either

(1) numbers of molecules (or ions or formula units) or

(2) numbers of moles, depending on your needs.

$$2\ H_{2(g)} + O_{2(g)} \rightarrow 2\ H_2O_{(l)}$$

2 molecules $H_{2(g)}$ + 1 molecule $O_{2(g)}$ → 2 molecules $H_2O_{(l)}$

2 moles $H_{2(g)}$ + 1 mole $O_{2(g)}$ → 2 moles $H_2O_{(l)}$

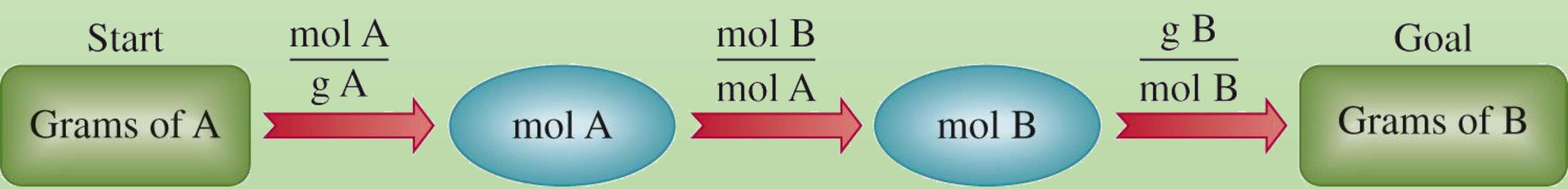
This relationship is made because of Avogadro's number (N_A)

Stoichiometry – setting up….

A $\longrightarrow$ **B**

To find the amount of B (one reactant or product) given the amount of A (another reactant or product):

1. Convert grams of A to moles of A → Using the molar mass of A
2. Convert moles of A to moles of B → Using the coefficients of the balanced chemical equation
3. Convert moles of B to grams of B → Using the molar mass of B



Solved Problem:

Propane, C_3H_8, is normally a gas, but it is sold as a fuel compressed as a liquid in steel cylinders. The gas burns according to the following equation:

$$C_3H_8(g) + 5O_2(g) \rightarrow 3CO_2(g) + 4H_2O(g)$$

How many grams of CO_2 are produced when 2.00 mols of propane are burned?

1) The equation is balanced.
2) Molar masses:
   C_3H_8: don't need mass for propane because mols are already given.
   CO_2: 1(12.01) + 2(16.00) = 44.01 g
3) Mol ratio needed is of C_3H_8 to CO_2, 1:3.
4) 1 mol of C_3H_8 produces 3 mols of CO_2.
5) Final step will be to covert mols CO_2 of to grams of CO_2.

$$2\,\text{mol}\,C_3H_8\,\frac{3\,\text{mol}\,CO_2}{1\,\text{mol}\,C_3H_8}\,\frac{44.01\,\text{g}\,CO_2}{1\,\text{mol}\,CO_2} = 264\,\text{g}\,CO_2$$

Solved Problem:

Propane, C_3H_8, is normally a gas, but it is sold as a fuel compressed as a liquid in steel cylinders. The gas burns according to the following equation:

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How many grams of O_2 are required to burn 20.0 g of propane?

Molar masses:

O_2 2(16.00) = 32.00 g

C_3H_8 3(12.01) + 8(1.008) = 44.094 g

1) Convert g of propane to mol of propane using molar mass of propane.
2) Find the mol ratio of propane to oxygen to find mols of oxygen.
3) Find the grams of oxygen using molar mass of oxygen.

$$20.0 \text{ g } C_3H_8 \frac{1 \text{ mol } C_3H_8}{44.094 \text{ g } C_3H_8} \frac{5 \text{ mol } O_2}{1 \text{ mol } C_3H_8} \frac{32.00 \text{ g } O_2}{1 \text{ mol } O_2} = 72.57223205 \text{ g } O_2$$

$$\boxed{72.6 \text{ g } O_2}$$

Stoichiometric Calculations - Mass to Mass

A chemist needs 58.75 grams of urea, how many grams of ammonia are needed to produce this amount?

$$2NH_{3(g)} + CO_{2(g)} \rightarrow (NH_2)_2CO_{(aq)} + H_2O_{(l)}$$

Strategy:

Grams urea → moles → mole ratio → grams

$$58.75 \text{ g } (NH_2)_2CO \times \frac{1 \text{ mol} (NH_2)_2CO}{58.06 \text{ g} (NH_2)_2CO} \times \frac{2 \text{ mol } NH_3}{1 \text{ mol } (NH_2)_2CO} \times \frac{17.04 \text{ g } NH_3}{1 \text{ mol } NH_3} = 34.49 \text{ g } NH_3$$

Review

- Chemical equations
- Mole concept and conversions
- Stoichiometry