Stoichiometry

Stoichiometry

- The word stoichiometry derives from two Greek words:
  - *Stoicheion* (meaning "element")
  - *Metron* (meaning "measure")

- Stoichiometry deals with calculations about the masses (sometimes volumes) of reactants and products involved in a chemical reaction.

- The most common stoichiometric problem will present you with a certain **amount of reactant** and then ask **how much product can be formed**.

Stoichiometry

Here is a generic chemical equation

$$2A + 2B \rightarrow 3C$$

- For every **2 moles** of A used, **3 moles** of C are formed
- For every **2 moles** of B used, then **3 moles** of C are formed.

$$\frac{n(B)}{n(C)} = \frac{2}{3}$$

- e.g. if 6 moles of C are formed, then 4 moles of B are used.

$$n(B) = 6x\frac{2}{3} = 4$$

Writing Mole Ratios

- Let's look at another equation:

$$2\ O_3 \rightarrow 3\ O_2$$

- The exact molar ratio you would use depends on how the problem is worded.
  - What is the molar ratio between O_3 and O_2? $\frac{2}{3}$ or 2 : 3
  - What is the molar ratio between O_2 and O_3? $\frac{3}{2}$ or 3 : 2
  - Often the mass of chemicals are given and they must be converted to moles before the question can be completed

    Typical question: Given 20.0g of A and sufficient B, how many grams of C can be produced?

Steps for solving Mass-Mass Stoichiometry Problems

1. Make sure the chemical equation is correctly **balanced**.
2. Underneath the compound in the equation and using the molar mass of the given substance, **convert** the **mass** given in the problem **to moles**
3. Construct a **molar proportion/ratio**. Use it to determine the number of moles of the unknown
4. Using the molar mass of the unknown substance, **convert moles** of the unknown **to mass**.

Sample Problem#1

Calculate the mass of nitrogen needed to produce 1000.0 g of ammonia gas.

$$1N_{2(g)} + 3H_{2(g)} \rightarrow 2NH_{3(g)}$$

unknown / **known**

$$\frac{n(N_2)}{n(NH_3)} = \frac{1}{2}$$

$$n = \frac{1}{2}(58.82\ \text{mol})$$

$$= 29.41\ \text{mol}\ N_2$$

m=1000.0g

M = 17.0 g/mol

n = m/M

= 1000.0g / 17.0g/mol

= 58.82 mol (1 extra SF)

Convert moles of N_2 to mass

m = n x M $M(N_2)$ = 2 x 14.0 = 28.0 g/mol

m = 29.41 mol x 28.0 g/mol

= 823.48

= 824 g (3 sig digits)

∴ 824 grams of N_2 are required.

Sample Problem#2

- Calculate the mass of water produced when 300.0 g of ethane is burned in excess oxygen.

$C_2H_{6(g)} + O_{2(g)} \rightarrow CO_{2(g)} + H_2O_{(l)}$

$2C_2H_{6(g)} + 7O_{2(g)} \rightarrow 4CO_{2(g)} + 6H_2O_{(l)}$

m=300.0g

M = 30.0 g/mol

n = m/M

= 300.0g / 30.0g/mol

= 10.00 mol (1 extra SF)

$$\frac{n(H_2O)}{n(C_2H_6)} = \frac{6}{2}$$

$$n(H_2O) = 10.00 \text{ mol} \times \frac{6}{2}$$

$$= 30.0 \text{ mol } H_2O$$

Convert moles of H_2O to mass

m = n x M $M(H_2O)$ = 2 x 1.0 + 16.0 = 18.0 g/mol

m = 30.0 mol x 18.0 g/mol

= 540.0 g

= 5.40×10^2 g (3 sig digits)

∴ 540 grams of H_2O will be produced.