Lesson 1 –Volume-volume stoichiometry

In order to solve a volume to volume stoichiometric problem we need.

- A balanced chemical equation

- The volume and concentration of one of the reacting solutions .

Mol = C X V

Let's try some exercises.

1. A 20.0 mL solution of NaCl <u>reacts exactly</u> 20.0 mL of a 0.100 M $AgNO_3$solution according to the equation below.
   $NaCl(aq) + AgNO_3(aq) \rightarrow AgCl(s) + NaNO_3(aq)$
   Find the concentration, in mol/L, of the NaCl solution.

   Step 1 derive the balanced chemical equation
   Since the balanced equation is already given skip to step 2
   Step 2 Find the mol of $AgNO_3$ that reacted
   => n = C X V = 0.100 X 0.0200 = 0.00200 = 2.00 X 10^{-3}mol
   Step 3 Using the ratio provided in the balanced equation calculate the mol of NaCl.
   => mol of $AgNO_3$ = mol of NaCl = 2.00 X 10^{-3}mol
   Step 4 Calculate the concentration of NaCl
   => C =n/V = 2.00 X 10^{-3}mol / 0.0200L = 0.100 M

2. 40.00 mL of a Na_2CO_3 solution completely reacts with a 30.00 mL 0.251 M HCl solution. Find the concentration, in mol/L, of the H_2CO_3 solution.
   Step 1 derive the balanced chemical equation
   $Na_2CO_3(aq) + 2HCl(aq) \rightarrow 2NaCl(aq) + H_2O(l) + CO_2(g)$
   Step 2 Find the mol of one of the reactants
   mol of HCl = C X V = 0.251mol/L X 0.0300L = 0.00753 mol
   Step 3 Using the ratio provided in the balanced equation to calculate the mol of the other reactant
   mol of Na_2CO_3 = ½ X 0.00753 = 0.00377 mol
   Step 4 Calculate the concentration of the second reactant
   concentration of Na_2CO_3 = 0.00377 mol / 0.0400L = 0.094M

3. Find the concentration, in %m/v, of an 80.00 mL sample of NaCl solution that <u>reacts exactly</u> with 48.00 mL of a 0.145 M $AgNO_3$ according to the equation below.
   $NaCl(aq) + AgNO_3(aq) \rightarrow AgCl(s) + NaNO_3(aq)$

   Step 1 derive the balanced chemical equation
   This already given so skip to step 2
   Step 2 Find the mol of one of the reactants
   mol of $AgNO_3$ = C X V = 0.145 M X 0.048L = 0.00696mol
   Step 3 Using the ratio provided in the balanced equation to calculate the mol of the other reactant
   mol of NaCl = 0.00696mol
   Step 4 Calculate the concentration of the second reactant
   => mass of NaCl = 0.00696mol X 58.5 = 0.4072 g
   => %m/v = (0.4072 / 80.00) X 100 = 0.509%m/v

4. What volume, in litres, of a 0.100 M Na_2CO_3 solution reacts exactly with 40.00 mL of a 0.521 M H_3PO_4 solution?
Step 1 derive the balanced chemical equation
$2H_3PO_4(aq) + 3Na_2CO_3(aq) \rightarrow 3H_2O(l) + 3CO_2(g) + 2Na_3PO_4(aq)$
Step 2 Find the mol of one of the reactants
mol of H_3PO_4 = C X V = 0.521 M X 0.0400 L = 0.02084 mol
Step 3 Using the ratio provided in the balanced equation to calculate the mol of the other reactant
=> mol of Na_2CO_3 = 3/2 X 0.02084 mol = 0.03126 mol
Step 4 Calculate the volume needed of the second reactant
=> (0.03126 /0.100 mol/L) = vol (L) = 0.3126L

5. What is the minimum amount, in mL, of a 0.621 M HCl solution that will react exactly with 50.00 mL of a 0.255 M Na_2CO_3 solution.
Step 1 derive the balanced chemical equation
$2HCl(aq) + Na_2CO_3(aq) \rightarrow 2NaCl(aq) + CO_2(g) + H_2O(l)$
Step 2 Find the mol of one of the reactants
mol of Na_2CO_3 = C X V = 0.255 X 0.0500 = 0.01275mol
Step 3 Using the ratio provided in the balanced equation to calculate the mol of the other reactant
Mol of HCl = 2 X 0.01275mol = 0.0255 mol
Step 4 Calculate the volume needed of the second reactant
=> V = mol/C = 0.0255mol / 0.621 mol/L = 0.0411 = 41.1mL

6. 60.00 mL of HCl acid solution reacts with exactly 60.00 mL of a 0.452 M K_2CO_3 solution. Calculate the concentration of the HCl solution in %m/v.
Step 1 derive the balanced chemical equation
$2HCl(aq) + K_2CO_3(aq) \rightarrow 2KCl(aq) + CO_2(g) + H_2O(l)$
Step 2 Find the mol of one of the reactants
mol of K_2CO_3 = C X V = 0.452 X 0.0600 = 0.02712
Step 3 Using the ratio provided in the balanced equation to calculate the mol of the other reactant
mol of HCl = 2 X 0.02712 mol = 0.05424 mol
Step 4 Calculate the concentration of the second reactant
=> mass of HCl = 0.05424 X 36.5 = 1.98g
=>%m/v = (1.98 / 60mL) X 100 = 3.30%m/v

7. A common brand of cleaner contains NaOH. 40.00 mL of this cleaner reacted exactly with 23.13 mL of 0.155 M HCl. Calculate the concentration of the NaOH in the original cleaner in mol/L
Step 1 derive the balanced chemical equation
$NaOH(aq) + HCl(aq) \rightarrow NaCl(aq) + H_2O(l)$
Step 2 Find the mol of one of the reactants
mol of HCl = C X V = 0.155 X 0.02313 = 0.00359 mol
Step 3 Using the ratio provided in the balanced equation to calculate the mol of the other reactant
mol of NaOH = 0.00359 mol
Step 4 Calculate the concentration of the second reactant
=> 0.00359 / 0.0400 = 8.96×10^{-2} M

Notice how all the problems stated above have two things in common.

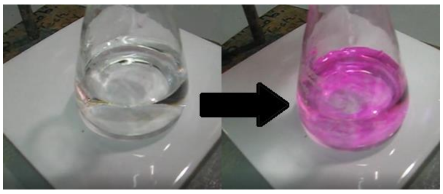
1. They give an accurate volume and concentration of one of the solutions.
2. They state that one solution reacts with exactly a given volume of another.

These two characteristics are experimentally determined using a titration procedure during which the following pieces of equipment are essential.

- A **burette**. This is glassware that accurately measures a variable volume of solution with a high degree of precision. Readings are taken to within two decimal places. The volume dispensed is known as a ***titre***.

- **Standard solution.** This solution has a concentration that is very accurately known. This precise concentration together with the accurate volume dispensed by the burette will allow us to calculate the mol of one of the reactants.

- **Indicator** – Is a substance that changes colour when the reactants have been mixed exactly in the correct stoichiometric ratio, as shown by a balanced chemical equation. A change of colour signals the end of the titration procedure. An indicator does not take part in the reaction between the two reactants given in the balanced chemical equation.



The colour change of each indicator differs. An indicator is carefully selected to match the chemical reaction being performed.