1.5 – Solutions

1.5.1 - Distinguish between the terms solute, solvent, solution and concentration (g dm^{-3} and mol dm^{-3})

Solute - This is the substance which has been dissolved.

Solvent - The bulk substance in which the solute was dissolved

Solution - This is made up of the solute and the solvent. The solution is called aqueous if the solvent is water

Concentration - This is an expression of how much solute there is dissolved in the solution. This can be expressed in g dm^{-3} or mol dm^{-3}.

1.5.2 - Solve problems involving concentration, amount of solute and volume of solution

$$C = \frac{n}{V} \quad \text{OR} \quad n = CV$$

C = concentration of solution - mol dm^{-3}
n = number of moles of solute - mol
V = volume of solution - dm^3

For example:

Sucrose ($C_{12}H_{22}O_{11}$) solution:

$m = 30.0\text{g } C_{12}H_{22}O_{11}$

$V = 200\text{cm}^3$

$$n = \frac{m}{M} = \frac{30.0}{342.34} = 0.0876 \text{ mol } C_{12}H_{22}O_{11}$$

$$C = \frac{n}{V} = \frac{0.0876}{0.200} = 0.438 \text{ mol dm}^{-3}$$

Calculating Concentrations of Components of Solutions

The concentration of individual ions in solution is <u>proportional to the chemical formula</u> of the compound. If two or more solutions are mixed and there is no chemical reaction, the concentration of each individual ion can be calculated by determining the total amount of that ion present and dividing by the final volume of the solution.

For example:

$$m(Al_2[SO_4]_3) = 40.0\,kg$$

$$V = 250.0\,dm^3$$

$$n = \frac{m}{M} = \frac{40\,000\,g}{342.14} = 116.9\text{ mol } Al(SO_4)_3$$

$$c = \frac{n}{V} = \frac{116.9}{250} = 0.4676\text{ mol dm}^{-3}\ Al(SO_4)_3$$

$$\therefore\ c(Al^{3+}) = 2 \times 0.4676 = 0.9352\text{ mol dm}^{-3}$$

$$\therefore\ c(SO_4^{2-}) = 3 \times 0.4676 = 1.403\text{ mol dm}^{-3}$$

Dilution of Solutions

When a solution is diluted, the number of moles of solution remains the same, but the volume changes.

$$c_1V_1 = c_2V_2$$

c_1 = initial concentration

V_1 = initial volume

c_2 = diluted concentration

V_2 = diluted volume

For this equation to work, the units must be constant, not necessarily mol dm^{-3} or dm^3

For example:

$c_1 = 0.20 \text{ mol dm}^{-3}$ $\quad c_2 = x$

$V_1 = 50 \text{ cm}^3$ $\quad V_2 = 250 \text{cm}^3$

$$c_2 = \frac{c_1 V_1}{V_2} = \frac{0.20 \times 50}{250} = 0.040 \text{ mol dm}^{-3}$$

Limiting Reagent with Solutions

$$NaCl_{(aq)} + AgNO_{3(aq)} \rightarrow AgCl_{(s)} + NaNO_{3(aq)}$$

$c(NaCl) = 0.496 \text{ mol dm}^{-3}$

$V(NaCl) = 0.018 \text{ dm}^3$

$c(AgNO_3) = 0.288 \text{ mol dm}^{-3}$

$V(AgNO_3) = 0.024 \text{ dm}^3$

$m(AgCl) = x$

$M(AgCl) = 143.3 \text{g mol}^{-1}$

$$c = \frac{n}{V}$$

$\therefore n(NaCl) = cV = 0.496 \times 0.018 = 8.93 \times 10^{-3} \text{ mol}$

$n(AgNO_3) = cV = 0.288 \times 0.024 = 6.91 \times 10^{-3} \text{ mol}$

NaCl is in excess, so $AgNO_3$ is the limiting reagent

$AgNO_3 : AgCl$ $\quad \therefore n(AgNO_3) = n(AgCl) = 6.91 \times 10^{-3} \text{ mol}$

$1 : 1$

$$6.91 \times 10^{-3} \times 143.32 = 0.990 \text{g } AgCl$$

Substance	Lead (II) Nitrate	Potassium Iodide
Volume	$20.0cm^3$	excess
Concentration	$0.250mol\ dm^{-3}$	$0.500mol\ dm^{-3}$

* Potassium Iodide is in excess

1. $Pb(NO_3)_{2\,(aq)} + 2KI_{(aq)} \rightarrow PbI_{2\,(s)} + 2KNO_{3\,(aq)}$

2. $c(Pb(NO_3)_2) = 0.250\ mol\ dm^{-3}$ $\quad m(PbI_2) = ?$

   $V(Pb(NO_3)_2) = 0.0200 dm^3$ $\quad M(PbI_2) = 460.99 g\ mol^{-1}$

3. $c(Pb(NO_3)_2) = \frac{n}{V}$

   $\therefore\ n(Pb(NO_3)_2) = cV = 0.250 \times 0.0200 = 5.00 \times 10^{-3} mol$

4. Mole ratio from equation:

   $\therefore\ n(PbI_2) = \frac{1}{1} \times (Pb(NO_3)_2) = 5 \times 10^{-3} mol$