Topic 3 – Moles
Revision Notes

1. Moles

- In Chemistry, amounts are measured in moles
- A mole contains 6.02×10^{23} particles. Particles can be atoms, molecules, ions or electrons
- For a solution, moles = concentration x volume/1000 (volume in cm^3)

2. Reacting Mass Calculations

Step 1 - Find the number of moles of the thing you are told about
Step 2 – Use the equation to find out the moles of the thing you are asked about.
Step 3 – Find the mass of the thing you are asked about.

Example

Work out the mass of HCl formed from 6.0g of hydrogen

$$H_2 + Cl_2 \rightarrow 2HCl$$

Step 1: Moles H_2 = 6.0 ÷ 2.0 = 3.0 (mass ÷ molar mass)
Step 2: Moles HCl = 3.0 x 2/1 (from equation) = 6.0
Step 3: Mass HCl = 6.0 x molar mass = 6 x 36.5 = 219g (moles x molar mass)

3. Titration Calculations

- Concentration is usually measured in moles of solute per cubic decimetre of solution, **mol dm^{-3}**
- A cubic decimetre, $1dm^3$, has the same volume as a litre i.e. $1000cm^3$
- The volume of a solution is often measured in cm^3. This needs to be converted to dm^3 by dividing by 1000 before calculating a concentration in mol dm^{-3}

Step 1 - Find the number of moles of the thing you know the concentration and volume of.
Step 2 – Use the equation to find out the moles of the thing you are asked about.
Step 3 – Find the unknown concentration or molar mass

Example

25 cm^3 of NaOH needed 21.5 cm^3 of 0.1 mol dm^{-3} H_2SO_4 for neutralisation. Calculate the concentration of the NaOH solution.

$$H_2SO_4 + 2NaOH \rightarrow 2NaCl + 2H_2O$$

Step 1: Moles H_2SO_4 = $0.1 \times 21.5 \div 1000 = 2.15 \times 10^{-3}$ (conc x vol ÷ 1000)
Step 2: Moles NaOH = $2.15 \times 10^{-3} \times 2$ (from equation) = 4.30×10^{-3}
Step 3: Conc NaOH = $4.30 \times 10^{-3} \div (25 \div 1000) = 0.172$ mol dm^{-3} (moles ÷ volume in dm^3)

4. Ideal Gas Equation

The ideal gas equation is:

$$PV = nRT$$

Where: P = pressure in Pa
V = volume in m^3 ($1\ m^3 = 10^3\ dm^3 = 10^6\ cm^3$)
n = number of moles
R = gas constant ($8.31\ J\ K^{-1}\ mol^{-1}$)
T = Kelvin temperature (°C + 273)

Example

0.166 mol of oxygen is in a sealed container whose volume is 1725 cm^3. The temperature is 300 K. Calculate the pressure of the oxygen inside the container.
(The gas constant R = 8.31 J K^{-1} mol^{-1})

PV = nRT
P = nRT/V

T has correct units but V is in cm^3 rather than m^3
1725 cm^3 = $1725 \times 10^{-6}\ m^3$
= $1.725 \times 10^{-3}\ m^3$

P = $0.166 \times 8.31 \times 300/(1.725 \times 10^{-3})$
= 239906 Pa
= 240 kPa

For a fixed number of moles of gas, the ideal gas equation reduces to:

$$P_1V_1/T_1 = P_2V_2/T_2$$

This version can be used to calculate the effect of changes in P, V or T on such a sample.

The ideal gas equation can be combined with $n = m/M_r$ or with ρ (density) = m/V

$$PV = mRT/M_r$$

$$P = \rho RT/M_r$$

If these versions are used, mass must be in grams and density in g m^{-3}

5) Percentage yield

- Most organic reactions do not give 100% conversion of reactant to product
- Reasons for this include the fact that most organic reactions are reversible, there may be side products and there will be loss of the desired product during purification

$$\textbf{\% yield} = \frac{\textbf{Actual moles of product}}{\textbf{Possible moles of product}} \times 100\%$$

Example

In the following reaction, 2.18g of bromoethane produce 0.75g of ethanol. Calculate the percentage yield.

$$CH_3CH_2Br + NaOH \rightarrow CH_3CH_2OH + NaBr$$

Moles of reactant (bromoethane)	= mass/molar mass
	= 2.18/109
	= 0.020 mol
Possible moles of ethanol	= 0.020 mol (from equation)
Actual moles of ethanol	= 0.75/46.0
	= 0.0163 mol
Percentage yield	= 0.0163/0.020 x 100%
	= 82%

6) Ionic equations

- Ionic equations leave out ions that are unchanged in a reaction. They give a clearer picture of what is happening in a reaction
- To go from a symbol equation to an ionic equation:
    - Split up anything that is (aq) and ionic (acids, alkalis and salts)
    - Cancel ions that are on both sides

Example

Symbol equation: $HCl(aq) + NaOH(aq) \rightarrow NaCl(aq) + H_2O(l)$

Split up into ions: $H^+(aq) + Cl^-(aq) + Na^+(aq) + OH^-(aq) \rightarrow Na^+(aq) + Cl^-(aq) + H_2O(l)$

Cancel Na^+ & Cl^-: $H^+(aq) + OH^-(aq) \rightarrow H_2O(l)$