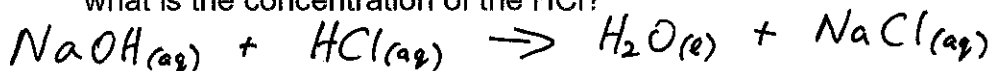


Year 12 Chemistry

Titration Practice Worksheet

1. If it takes 54 mL of 0.1 M NaOH to neutralise 125 mL of an HCl solution, what is the concentration of the HCl?



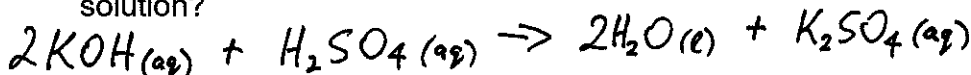
$$n(\text{NaOH}) = cV = 0.1 \times 0.054 = 0.0054 \text{ mol}$$

$$SR = \frac{1}{1} = 1$$

$$n(\text{HCl}) = 0.0054 \text{ mol L}^{-1}$$

$$c(\text{HCl}) = \frac{n}{V} = 0.0054 / 0.125 = 0.043 \text{ mol L}^{-1} = 4 \times 10^{-2} \text{ mol L}^{-1} \text{ (1 s.f.)}$$

2. If it takes 50 mL of 0.5 M KOH solution to completely neutralize 125 mL of sulfuric acid solution (H_2SO_4), what is the concentration of the H_2SO_4 solution?



$$n(\text{KOH}) = cV = 0.5 \times 0.050 = 0.025 \text{ mol}$$

$$SR = \frac{1}{2}$$

$$n(\text{H}_2\text{SO}_4) = \frac{1}{2} \times 0.025 = 0.0125 \text{ mol}$$

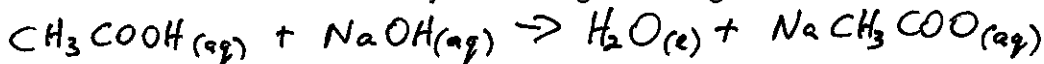
$$c(\text{H}_2\text{SO}_4) = \frac{n}{V} = 0.0125 / 0.125 = 0.1 = 1 \times 10^{-1} \text{ mol L}^{-1} \text{ (1 s.f.)}$$

3. Explain the difference between an endpoint and equivalence point in a titration.

The endpoint is the physical sign, such as a change in the colour of an indicator, that the equivalence point has been reached.

The equivalence point is when the reactants are present in their stoichiometric ratio.

4. 25 cm³ of a sample of vinegar (CH_3COOH) was pipetted into a volumetric flask and the volume was made up to 250 cm³. This solution was placed in a burette and 13.9 cm³ were required to neutralise 25 cm³ of 0.1 mol dm⁻³ NaOH. Calculate the molarity of the original vinegar solution.



$$n(\text{NaOH}) = cV = 0.1 \times 0.025 = 0.0025 \text{ mol}$$

$$SR = \frac{1}{1} = 1$$

$$n(\text{CH}_3\text{COOH, dilute}) = 0.0025 \text{ mol}$$

$$c(\text{CH}_3\text{COOH, dilute}) = \frac{n}{V} = 0.0025 / 0.0139 = 0.17986 \text{ mol L}^{-1}$$

Let solⁿ 1 be undiluted vinegar, solⁿ 2 be diluted vinegar.

$$C_1 = ? \cdot V_1 = 25 \cdot C_2 = 0.17986 \cdot V_2 = 250$$

$$C_1 V_1 = C_2 V_2$$

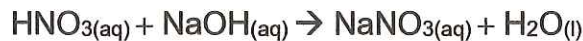
$$C_1 = \frac{C_2 V_2}{V_1} = \frac{0.17986 \times 250}{25} = 1.7986 = 2 \text{ mol L}^{-1} \text{ (1 s.f.)}$$

5. Volumetric analysis is used for the quantitative determination of PbCO_3 in mineral ores. A 3.15 g sample of an ore was analysed to determine the percentage of PbCO_3 present, using the following procedure:

Step 1: An excess of $0.6293 \text{ mol L}^{-1} \text{ HNO}_3(\text{aq})$ was added to the sample. The equation for this reaction is shown below:



Step 2: When the reaction was complete, the unreacted HNO_3 was titrated with $0.1423 \text{ mol L}^{-1} \text{ NaOH}(\text{aq})$. The equation for the titration reaction is shown below:



State one observation that would indicate that the reaction in Step 1 was complete.

Bubbles of a colourless, odourless gas are no longer produced.

The volume of HNO_3 added in Step 1 was 25.00 mL. Calculate the number of moles of HNO_3 added to the sample.

$$\begin{aligned} n &= cV = 0.6293 \times 0.02500 \\ &= 0.01573 \text{ mol (4 sf)} \end{aligned}$$

The volume of NaOH required was 23.67 mL. Calculate the number of moles of NaOH that reacted with the HNO_3 in Step 2.

$$\begin{aligned} n &= cV = 0.1423 \times 0.02367 \\ &= 0.003368 \text{ mol (4 sf)} \end{aligned}$$

Calculate the number of moles of unreacted HNO_3 that remained after Step 1. Then, calculate the number of moles of HNO_3 that reacted during Step 1.

$$\begin{aligned} n(\text{unreacted HNO}_3) &= n(\text{NaOH}) = 0.0033682 \text{ mol} \\ n(\text{HNO}_3 \text{ that reacted with PbCO}_3) &= 0.01573 - 0.0033682 \\ &= 0.01236 \text{ mol (4 sf)} \end{aligned}$$

Calculate the number of moles of PbCO_3 in the ore sample.

$$\begin{aligned} \text{SR} = \frac{1}{2} \quad n(\text{PbCO}_3) &= 0.0123618 \times \frac{1}{2} \\ &= 0.0061809 \text{ mol (4 sf)} \end{aligned}$$

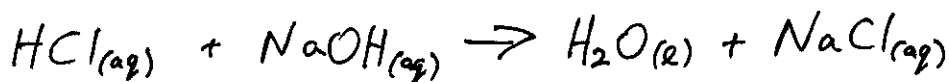
Calculate the percentage, by mass, of PbCO_3 in the ore sample.

$$\begin{aligned} m(\text{PbCO}_3) &= nM = 0.0061809 \times (207.2 + 12.01 + 48) \\ &= 1.6515982 \text{ g} \end{aligned}$$

$$\% \text{ by mass of PbCO}_3 \text{ in sample} = \frac{1.6515982}{3.15} \times 100$$

$$\begin{aligned} &= 52.4 \% \\ &\text{(3 s.f.)} \end{aligned}$$

6. 0.80 g of impure chalk was reacted with 100 cm³ of 1 mol dm⁻³ hydrochloric acid (an excess). The mixture was filtered into a volumetric flask and made up to 250 cm³. A 25.0 cm³ portion of the solution required 8.5 cm³ of 1 mol dm⁻³ sodium hydroxide solution for neutralisation. What is the percentage of calcium carbonate in the impure chalk?



$$n(\text{NaOH}) = cV = 1 \times 0.0085 = 0.0085 \text{ mol}$$

$$SR = \frac{1}{1} = 1$$

$$n(\text{HCl after reaction with chalk}) = 0.0085 \text{ mol}$$

$$c(\text{HCl after reaction with chalk}) = \frac{n}{V} = \frac{0.0085}{0.025}$$

$$= 0.34 \text{ mol L}^{-1}$$

$$n(\text{HCl in 250 mL vol. flask after reaction with chalk})$$

$$= cV = 0.25 \times 0.34 = 0.085 \text{ mol}$$

$$n(\text{HCl before reaction with chalk}) = cV$$

$$= 1 \times 0.1$$

$$= 0.1 \text{ mol}$$

$$n(\text{HCl used in reaction with chalk}) = 0.1 - 0.085$$

$$= 0.015 \text{ mol}$$



$$n(\text{CaCO}_3) = \frac{1}{2} \times 0.015 = 0.0075 \text{ mol}$$

$$m(\text{CaCO}_3) = nM = 0.0075 \times (40.08 + 12.01 + 48)$$

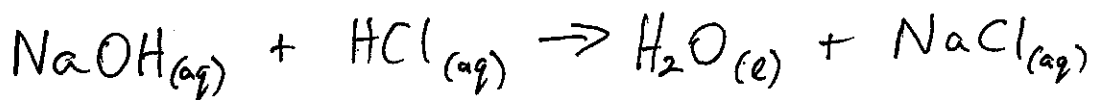
$$= 0.750675 \text{ g}$$

$$\% \text{ CaCO}_3 \text{ in chalk} = \frac{0.750675}{0.80} \times 100 \text{ Page | 3}$$

$$= 9 \times 10^1 \% \text{ (1 s.f.)}$$

$$SR = \frac{1}{2}$$

7. 0.601 g of an impure sample of ammonium chloride were boiled with 10.0 cm³ of 1.04 mol dm⁻³ aqueous sodium hydroxide until no more ammonia was evolved. Afterwards the solution was titrated with 0.101 mol dm⁻³ hydrochloric acid, 26.25 cm³ of which were needed to reach an end-point with methyl orange. Calculate the percentage by mass of ammonium chloride in the impure sample.



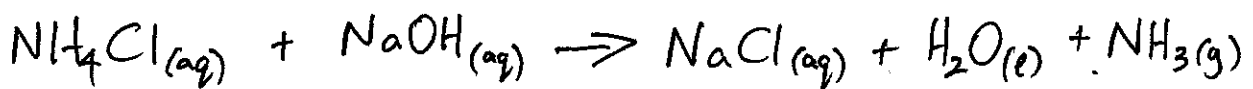
$$n(\text{HCl}) = cV = 0.101 \times 0.02625 = 0.00265125 \text{ mol}$$

$$SR = \frac{1}{1} = 1$$

$$n(\text{NaOH remaining after reaction with NH}_4\text{Cl}) = 0.00265125 \text{ mol}$$

$$\begin{aligned} n(\text{NaOH before reaction with NH}_4\text{Cl}) &= cV \\ &= 1.04 \times 0.010 \\ &= 0.0104 \text{ mol} \end{aligned}$$

$$\begin{aligned} n(\text{NaOH used in reaction with NH}_4\text{Cl}) &= 0.0104 - 0.00265125 \\ &= 0.00774875 \text{ mol} \end{aligned}$$



$$SR = \frac{1}{1} = 1$$

$$n(\text{NH}_4\text{Cl}) = 0.00774875 \text{ mol}$$

$$\begin{aligned} m(\text{NH}_4\text{Cl}) &= nM = 0.00774875 \times (14.01 + 4.032 + 35.45) \\ &= 0.414496 \text{ g} \end{aligned}$$

$$\% \text{ composition by mass} = \frac{0.414496}{0.601} \times 100$$

$$= 68.977\%$$

$$= 6.90 \times 10^1 \text{ (3 sf)}$$