Answers

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?

$NaOH_{(aq)} + HCl_{(aq)} \rightarrow H_2O_{(l)} + NaCl_{(aq)}$

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

$SR = 1/1 = 1$

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

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

$2KOH_{(aq)} + H_2SO_{4(aq)} \rightarrow 2H_2O_{(l)} + K_2SO_{4(aq)}$

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

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

$n(H_2SO_4) = \frac{1}{2} \times 0.025 = 0.0125$ mol

$c(H_2SO_4) = \frac{n}{V} = 0.0125/0.125 = 0.1 = 1 \times 10^{-1}$ mol L^{-1} (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 stochiometric ratio.

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

$CH_3COOH_{(aq)} + NaOH_{(aq)} \rightarrow H_2O_{(l)} + NaCH_3COO_{(aq)}$

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

$SR = 1/1 = 1$

$n(CH_3COOH, \text{dilute}) = 0.0025$ mol

$c(CH_3COOH, \text{dilute}) = n/V = 0.0025/0.0139 = 0.17986$ mol L^{-1}

Let sol^n 1 be undiluted vinegar, sol^n 2 be diluted vinegar.

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

$C_1V_1 = C_2V_2$

$C_1 = \frac{C_2V_2}{V_1} = \frac{0.17986 \times 0.250}{0.025} = 1.7986 = 2$ mol L^{-1} (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 mol L^{-1} $HNO_{3(aq)}$ was added to the sample. The equation for this reaction is shown below:

$$2HNO_{3(aq)} + PbCO_{3(s)} \rightarrow Pb(NO_3)_{2(aq)} + H_2O_{(l)} + CO_{2(g)}$$

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

$$HNO_{3(aq)} + NaOH_{(aq)} \rightarrow NaNO_{3(aq)} + H_2O_{(l)}$$

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.

$n = cV = 0.6293 \times 0.02500$

$= 0.01573$ mol (4sf)

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.

$n = cV = 0.1423 \times 0.02367$

$= 0.003368$ mol (4 sf)

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.

n(unreacted HNO_3) = n(NaOH) = 0.0033682 mol

n(HNO_3 that reacted with $PbCO_3$) = 0.01573 − 0.0033682

= 0.01236 mol (4 sf)

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

SR = $\frac{1}{2}$ $n(PbCO_3) = 0.0123618 \times \frac{1}{2}$

= 0.006181 mol (4 sf)

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

$m(PbCO_3) = nM = 0.0061809 \times (207.2 + 12.01 + 48)$

$= 1.6515982$ g

% by mass of $PbCO_3$ in sample $= \frac{1.6515982}{3.15} \times 100$

= 52.4 %

(3 s.f.)

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

$HCl_{(aq)} + NaOH_{(aq)} \rightarrow H_2O_{(l)} + NaCl_{(aq)}$

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

$SR = 1/1 = 1$

n(HCl after reaction with chalk) = 0.0085 mol

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

$= 0.34$ molL^{-1}

n(HCl in 250mL vol. flask after reaction with chalk)

$= cV = 0.25 \times 0.34 = 0.085$ mol

n(HCl before reaction with chalk) = cV

$= 1 \times 0.1$

$= 0.1$ mol

n(HCl used in reaction) with chalk $= 0.1 - 0.085$

$= 0.015$ mol

$CaCO_{3(s)} + 2HCl_{(aq)} \rightarrow CaCl_{2(aq)} + CO_{2(g)} + H_2O_{(l)}$

SR = 1/2

$n(CaCO_3) = \frac{1}{2} \times 0.015 = 0.0075$ mol

$m(CaCO_3) = nM = 0.0075 \times (40.08 + 12.01 + 48)$

$= 0.750675$ g

% $CaCO_3$ in chalk $= \frac{0.750675}{0.80} \times 100$

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

7. 0.601 g of an impure sample of ammonium chloride were boiled with 10.0 cm^3 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 cm^3 of which were needed to reach an end-point with methyl orange. Calculate the percentage by mass of ammonium chloride in the impure sample.

$$NaOH_{(aq)} + HCl_{(aq)} \rightarrow H_2O_{(l)} + NaCl_{(aq)}$$

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

$SR = 1/1 = 1$

n(NaOH remaining after reaction with NH_4Cl) $= 0.00265125$ mol

n(NaOH before reaction with NH_4Cl) $= cV$

$= 1.04 \times 0.010$

$= 0.0104$ mol

n(NaOH used in reaction with NH_4Cl)

$= 0.0104 - 0.00265125$

$= 0.00774875$ mol

$$NH_4Cl_{(aq)} + NaOH_{(aq)} \rightarrow NaCl_{(aq)} + H_2O_{(l)} + NH_{3(g)}$$

$SR = 1/1 = 1$

$n(NH_4Cl) = 0.00774875$ mol

$m(NH_4Cl) = nM = 0.00774875 \times (14.01 + 4.032 + 35.45)$

$= 0.414496$ g

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

$= 68.977\%$

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