

Calculating purity of a sample of sulphuric acid

A student carried out an experiment to try to find the concentration of a sample of concentrated sulphuric acid supplied by a chemical manufacturer.

- a) 1.00cm^3 of the acid was added to pure water and then diluted to a total volume of 250cm^3 .
Suggest suitable apparatus which could have been used to measure the 250cm^3 of solution.

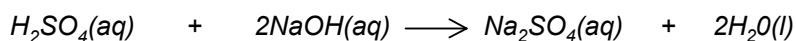
250cm^3 volumetric flask.

- b) The student then measured out 25.0cm^3 portions of this diluted acid and titrated them with 0.200mol dm^{-3} sodium hydroxide solution, using a suitable indicator. The average volume of sodium hydroxide required was 18.5cm^3 .

Equation:	$\text{H}_2\text{SO}_4 + 2\text{NaOH} \longrightarrow \text{Na}_2\text{SO}_4 + 2\text{H}_2\text{O}$
Ratio:	1 : 2
Moles:	$1.85 \times 10^{-3} : 0.2 \times 18.5/1000 = 3.7 \times 10^{-3}$

moles H_2SO_4 is $1/2$ this because of 2:1 ratio

- i) Write a balanced equation, including state symbols, for the reaction which occurred during the titration.



- ii) Calculate the number of moles of sodium hydroxide in 18.5cm^3 of the 0.200mol dm^{-3} sodium hydroxide solution.

$$\text{moles NaOH} = 0.2 \times 18.5/1000$$

$$= 3.7 \times 10^{-3} \text{ moles NaOH}$$

- iii) Calculate the number of moles of sulphuric acid in 25.0cm^3 of the dilute solution.

$$\text{moles H}_2\text{SO}_4 \text{ is } 1/2 \text{ the number of moles of NaOH}$$

$$3.7 \times 10^{-3} / 2 = \underline{1.85 \times 10^{-3}} \text{ moles H}_2\text{SO}_4$$

this is in 25cm^3

b iv) Calculate the number of moles of sulphuric acid in 1000cm³ of the original concentrated acid.

In the 250cm³ volumetric flask there would have been 10x the amount of sulphuric acid there was in the 25cm³ samples.

$$10 \times 1.85 \times 10^{-3} = 1.85 \times 10^{-2} \text{ moles } H_2SO_4$$

All of this acid originally came from the 1cm³ sample.

Therefore there was 1.85 x 10⁻² moles H₂SO₄ in 1cm³

There would be 1000x this in 1000cm³

$$\begin{aligned} 1000 \times 1.85 \times 10^{-2} \\ = 18.5 \text{ moles in } 1000\text{cm}^3 \\ = \underline{18.5 \text{ moldm}^{-3}} \end{aligned}$$

c) 'Universal Indicator' used for the first titration was found to be unsuitable.

i) Why is 'Universal Indicator' unsuitable for this titration?

Universal indicator changes colour over a range of pH values. Therefore it would not give a clear endpoint.

ii) Suggest a more suitable indicator.

Bromothymol blue would be more suitable. It changes from yellow (acid) to blue (alkaline) at about pH 7.

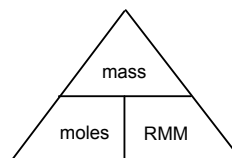
d) i) Sulphuric acid has a density of 1.84gcm⁻³ and a molar mass of 98 gmol⁻¹.

Calculate the number of moles of pure sulphuric acid in 1000cm³.

$$\begin{array}{l} H_2SO_4(l) \quad 1.84g : 1cm^3 \\ \quad \quad \quad 1840g : 1000cm^3 \end{array}$$

$$RMM H_2SO_4 = 98 \text{ gmol}^{-1}$$

$$\begin{aligned} \text{moles} &= \text{mass} / RMM \\ &= 1840 / 98 \\ &= 18.8 \text{ moles in } 1000\text{cm}^3 \\ &= 18.8 \text{ moldm}^{-3} \end{aligned}$$



ii) Compare the answer with your answer to b iv) and suggest a reason for any difference.

This value (18.8moldm⁻³) is slightly above the value from the sample in the experiment (18.5moldm⁻³).

This could be because the sample was not pure.

Alternatively, it could be that not all of the 1cm³ sulphuric acid sample was transferred to the volumetric flask.

Therefore the calculated value is slightly below the actual value.