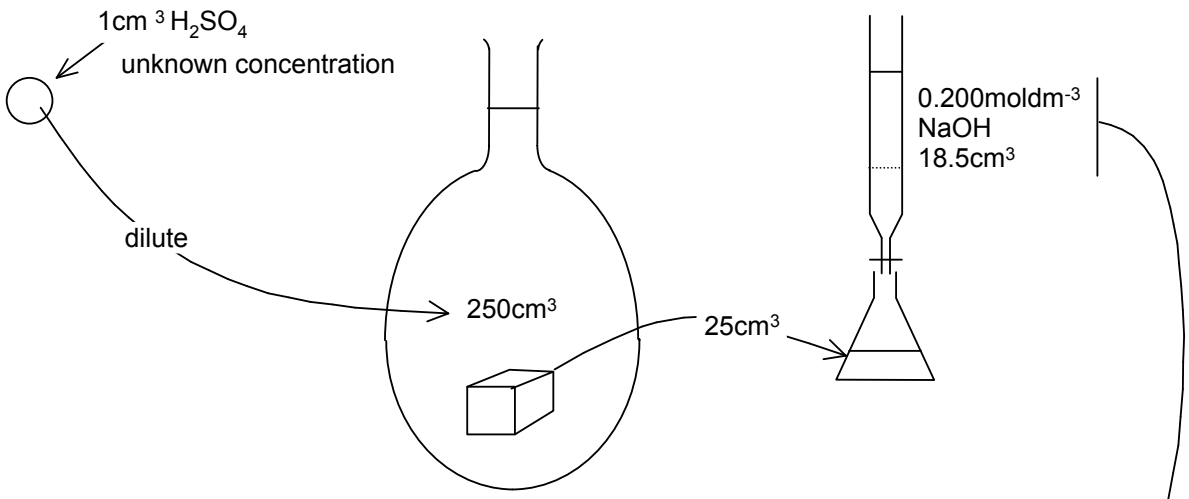
Calculating purity of a sample of sulphuric acid

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 0.200 moldm^{-3} sodium hydroxide solution, using a suitable indicator. The average volume of sodium hydroxide required was 18.5cm^3.



Equation:	H_2SO_4	+	2NaOH	⟶	Na_2SO_4	+	$2H_2O$
Ratio:	1	:	2				
Moles:	1.85 x 10-3	:	0.2 x 18.5/1000 = 3.7 x 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.

$H_2SO_4(aq)$ + $2NaOH(aq)$ ⟶ $Na_2SO_4(aq)$ + $2H_20(l)$

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

moles NaOH = 0.2 x 18.5/1000

= 3.7 x 10-3 moles NaOH

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

moles H_2SO_4 is $^1/_2$ the number of moles of NaOH

3.7 x 10^{-3} / 2 = <u>1.85 x 10^{-3}</u> moles H_2SO_4

this is in 25cm^3

b iv) Calculate the number of moles of sulphuric acid in 1000cm^3 of the original concentrated acid.

In the 250cm^3 volumetric flask there would have been 10x the amount of sulphuric acid there was in the 25cm^3 samples.

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

All of this acid originally came from the 1cm^3 sample.

Therefore there was 1.85×10^{-2} moles H_2SO_4 in 1cm^3

There would be 1000x this in 1000cm^3

$1000 \times 1.85 \times 10^{-2}$

= 18.5moles in 1000cm^3

= 18.5 moldm^{-3}

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.

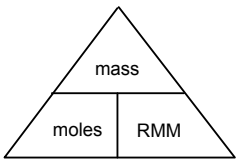
d) i) Sulphuric acid has a density of 1.84gcm^{-3} and a molar mass of 98 gmol^{-1}.
Calculate the number of moles of pure sulphuric acid in 1000cm^3.

$H_2SO_4(l)$ 1.84g : 1cm^3

1840g : 1000cm^3

RMM H_2SO_4 = 98 gmol^{-1}

moles = mass / RMM
= 1840 / 98
= 18.8 moles in 1000cm^3
= 18.8 moldm^{-3}



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 1cm^3 sulphuric acid sample was transferred to the volumetric flask.
Therefore the calculated value is slightly below the actual value.