



Scaffolding titration calculations

Learning objectives

- 1 Explore the table method for structuring titration calculations
- 2 Identify values for concentrations and volumes of solution and correctly identify which reactant these values apply to
- 3 Use $n = \frac{cV}{1000}$ to carry out calculations involving moles (n), concentration (in mol/dm³) and volume (in cm³)

Introduction

Titration calculations can be challenging as it can be difficult to work out where to begin. You will explore a method to scaffold the calculations and use it to calculate the concentration of one of the solutions.

Before you start, you need to remember the formula for calculating the concentration of a solution. Volumes in chemistry are usually measured in centimetres cubed, cm³. Concentration has the units, moles per decimetre cubed, mol/dm³. There are 1000 cm³ in 1 dm³. The formula used to move between moles, concentration and volume has a factor of 1000 in it.

$$\text{number of moles} = \frac{\text{concentration} \times \text{volume}}{1000}$$
$$n = \frac{cV}{1000}$$

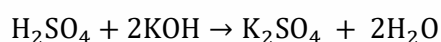
The table method

The table can help you to extract the important information from the question and find out where to start the calculation.

Example

A student titrated a 25.0 cm³ sample of sulfuric acid, H₂SO₄, with a 0.102 mol/dm³ solution of potassium hydroxide, KOH. The mean volume of potassium hydroxide required was 23.1 cm³.

The equation for the reaction is:



Calculate the concentration of the sulfuric acid.



The information from the question is transferred to the table. The ratio of moles comes from the balanced equation:

	H₂SO₄	KOH
Concentration (mol/dm ³)		0.102
Volume (cm ³)	25.0	23.1
<i>n</i> (moles)		
Ratio	1	2

You can start by calculating the number of moles of KOH.

Using $n = \frac{cV}{1000}$ you get 2.36×10^{-3} moles of KOH.

Using the ratios on the final row, you can see that 1 mole of H₂SO₄ reacts with 2 moles of KOH. So to get the number of moles of H₂SO₄ you must divide by 2.

	H₂SO₄	KOH
Concentration (mol/dm ³)		0.102
Volume (cm ³)	25.0	23.1
<i>n</i> (moles)	1.18×10^{-3}	2.36×10^{-3}
Ratio	1	2

The final step is to rearrange the formula $n = \frac{cV}{1000}$ to make *c* the subject and then use the values for H₂SO₄ to make the final calculation.

$$c = \frac{1000n}{V}$$

$$c = \frac{1000 \times 0.00118}{25.0}$$

$$c = 0.047 \text{ mol/dm}^3$$

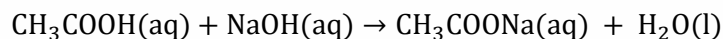
	H₂SO₄	KOH
Concentration (mol/dm ³)	0.047	0.102
Volume (cm ³)	25.0	23.1
<i>n</i> (moles)	1.18×10^{-3}	2.36×10^{-3}
Ratio	1	2



Questions

Now practise using the table method for calculations by answering the following questions.

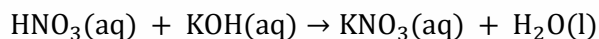
1. Ethanoic acid is neutralised by sodium hydroxide, as shown by the equation.



12.50 cm³ of ethanoic acid neutralised 25.00 cm³ of sodium hydroxide of concentration 0.22 mol/dm³. Calculate the concentration of the ethanoic acid in mol/dm³.

	CH ₃ COOH	NaOH
Concentration (mol/dm ³)		0.22
Volume (cm ³)	12.5	25
n (moles)		
Ratio	1	1

2. 30.0 cm³ of potassium hydroxide solution neutralised 25.0 cm³ of dilute nitric acid. The concentration of the dilute nitric acid was 2.0 mol/dm³.

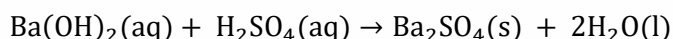


Calculate the concentration of the potassium hydroxide solution in mol/dm³.

	HNO ₃	KOH
Concentration (mol/dm ³)		
Volume (cm ³)		
n (moles)		
Ratio	1	1



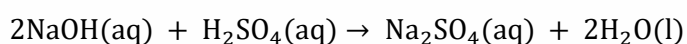
3. Barium sulfate can be made by adding barium hydroxide solution to dilute sulfuric acid. The balanced chemical equation for the reaction is



25.0 cm³ of 0.55 mol/dm³ sulfuric acid reacted with 10.0 cm³ of barium hydroxide. Calculate the concentration of the barium hydroxide.

	Ba(OH) ₂	H ₂ SO ₄
Concentration (mol/dm ³)		
Volume (cm ³)		
n (moles)		
Ratio		

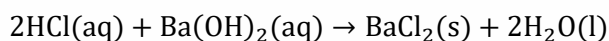
4. A student titrated 25.0 cm³ portions of dilute sulfuric acid with a 0.110 mol/dm³ sodium hydroxide solution. The equation for the reaction is



22.15 cm³ of sodium hydroxide was needed. Calculate the concentration of the sulfuric acid in mol/dm³.

	H ₂ SO ₄	NaOH
Concentration (mol/dm ³)		
Volume (cm ³)		
n (moles)		
Ratio		

5. Barium chloride can be made by adding barium hydroxide solution to dilute hydrochloric acid. The balanced chemical equation for the reaction is



25.0 cm³ of 1.0 mol/dm³ hydrochloric acid was reacted with 15.0 cm³ of barium hydroxide. Calculate the concentration of the barium hydroxide.