



14–16 years

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 $n = \frac{c V}{1000}$ to carry out calculations involving moles (n), concentration (in mol/dm³) and volume (in cm³)

Using a scaffolded method for titration calculations

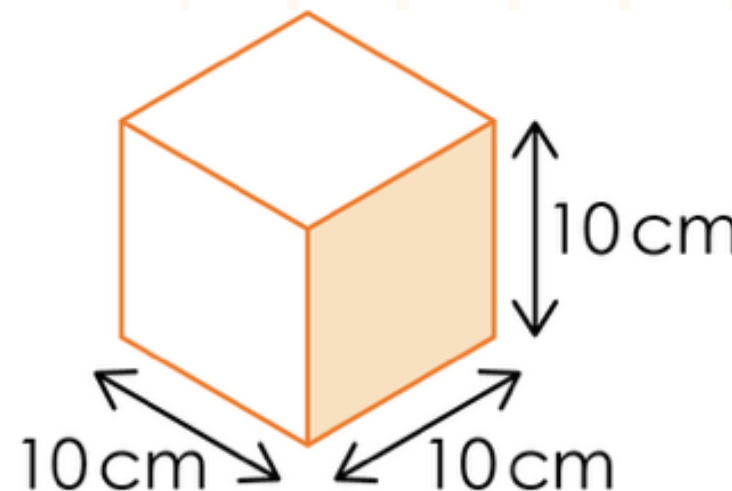
Titration calculations can be challenging as it can be difficult to work out where to begin.

In this lesson, 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 will need to remember the formula for calculating the concentration of a solution.

The formula relating moles, concentration and volume

- Volumes in chemistry are usually measured in centimetres cubed, cm^3 .
- Concentration has the units, moles per decimetre cubed, mol/dm^3 .
- A decimetre is 10 cm.
A decimetre cubed is 1000 cm^3 .
- This means that calculations involving both concentration and volume must include a factor of 1000.



$$n = \frac{cV}{1000}$$

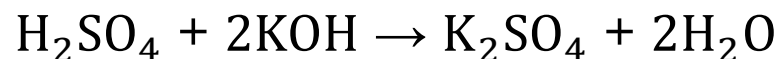
- n = number of moles
- c = concentration in mol dm^3
- V = volume in cm^3

The problem

A student titrated a 25.0 cm^3 sample of sulfuric acid, H_2SO_4 , with a 0.102 mol/dm^3 solution of potassium hydroxide, KOH .

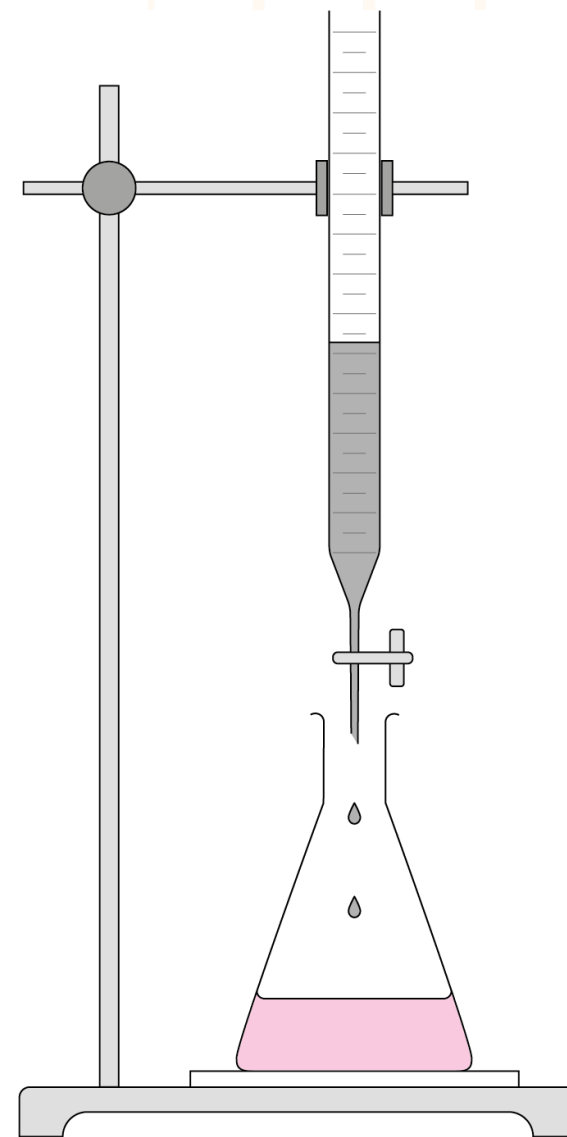
The mean volume of potassium hydroxide required was 23.1 cm^3 .

The equation for the reaction is



Calculate the concentration of the sulfuric acid.

What do you need to know to tackle this calculation?



Scaffolding titration calculations

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

Find the numbers for these in the text of the question.

Write the formulas of the acid and alkali in these columns

	Acid	Alkali
Concentration (mol/dm ³)		
Volume (cm ³)		
Moles		
Ratio		

You won't have anything in this row – moles are calculated in the next step.

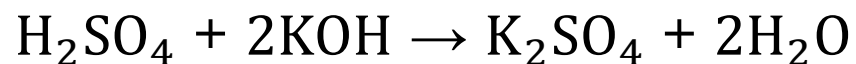
These are the multipliers from the symbol equation.

Returning to the titration problem

A student titrated a 25.0 cm^3 sample of sulfuric acid, H_2SO_4 , with a 0.102 mol/dm^3 solution of potassium hydroxide, KOH .

23.1 cm^3 was the mean volume of potassium hydroxide required.

The equation for the reaction is:



Calculate the concentration of the sulfuric acid.

	H_2SO_4	KOH
Concentration (mol/dm^3)		0.102
Volume (cm^3)	25	23.1
Moles		
Ratio	1	2

Next steps

You start the calculation using the substance for which you know both a concentration and a volume.

$$\text{Using } n = \frac{cV}{1000}$$

$$n(\text{KOH}) = \frac{0.102 \times 23.1}{1000}$$

$$= 2.36 \times 10^{-3} \text{ moles of KOH.}$$

	H ₂ SO ₄	KOH
Concentration (mol/dm ³)		0.102
Volume (cm ³)	25	23.1
Moles		2.36×10^{-3}
Ratio	1	2

Using the mole ratio

Using the ratios in the final row, you can see that 1 mole of H_2SO_4 reacts with 2 moles of KOH .

So, to get the number of moles of H_2SO_4 you must divide by 2.

	H_2SO_4	KOH
Concentration (mol/dm ³)		0.102
Volume (cm ³)	25	23.1
Moles	1.18×10^{-3}	2.36×10^{-3}
Ratio	1	2

The final step

Now that you have both the moles and volume of H_2SO_4 it is possible to calculate the concentration using the rearranged version of the formula.

$$n = \frac{cV}{1000}$$

rearranges to:

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

	H_2SO_4	KOH
Concentration (mol/dm ³)		0.102
Volume (cm ³)	25	23.1
Moles	1.18×10^{-3}	2.36×10^{-3}
Ratio	1	2

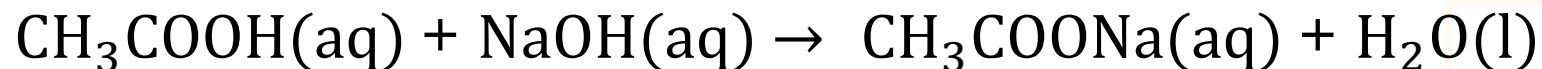
Using this formula, you get the final answer:

$$c(\text{H}_2\text{SO}_4) = \frac{1000 \times 0.00118}{25}$$

$$c(\text{H}_2\text{SO}_4) = 0.047 \text{ mol/dm}^3$$

Question 1

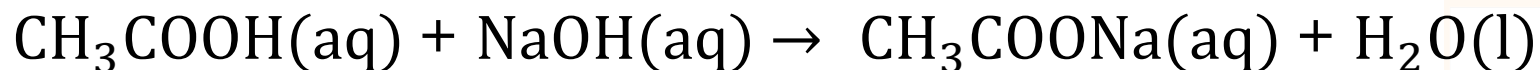
Ethanoic acid is neutralised by sodium hydroxide, as shown by the equation:



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.

Question 1

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

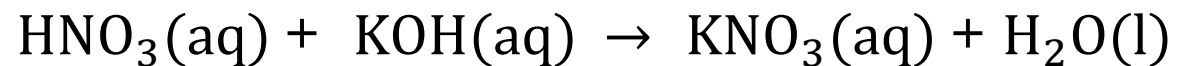


12.50 cm³ of ethanoic acid neutralised 25.00 cm³ of sodium hydroxide of concentration 0.22 mol/dm³. Calculate the concentration of the ethanoic acid in mol/dm³.

	CH ₃ COOH	NaOH
Concentration (mol/dm ³)		0.22
Volume (cm ³)	12.50	25.00
Moles		
Ratio	1	1

Question 2

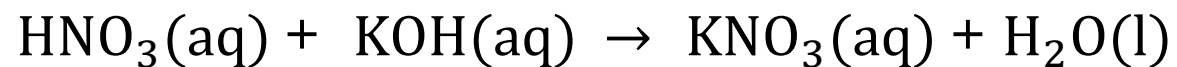
30.0 cm³ of potassium hydroxide solution neutralised 25.0 cm³ of dilute nitric acid. The concentration of the dilute nitric acid was 2.0 mol/dm³.



Calculate the concentration of the potassium hydroxide solution in moles per dm³.

Question 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.

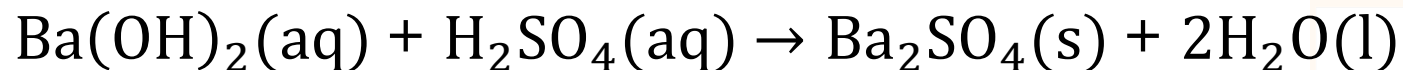


Calculate the concentration of the potassium hydroxide solution in moles per dm³.

	HNO₃	KOH
Concentration (mol/dm ³)	2.0	
Volume (cm ³)	25.00	30.00
Moles		
Ratio	1	1

Question 3

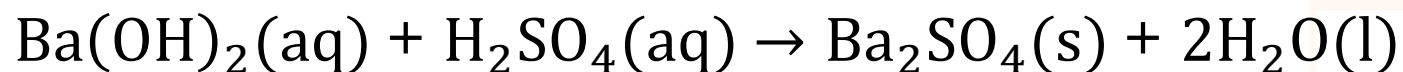
Barium sulfate can be made by adding barium hydroxide solution to dilute sulfuric acid. The balanced chemical equation for the reaction is:



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

Question 3

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

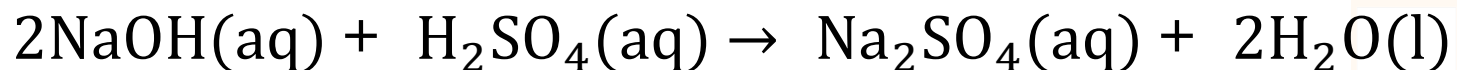


25.0 cm³ of 0.55 mol/dm³ sulfuric acid was reacted with 10.0 cm³ of barium hydroxide. Calculate the concentration of the barium hydroxide.

	Ba(OH) ₂	H ₂ SO ₄
Concentration (mol/dm ³)		0.55
Volume (cm ³)	10.00	25.00
Moles		
Ratio	1	1

Question 4

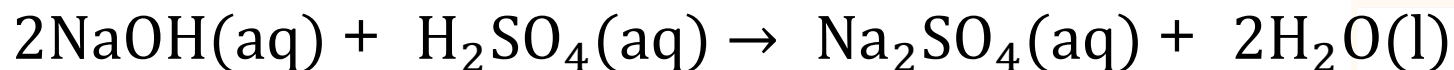
A student titrated 25.0 cm³ portions of dilute sulfuric acid with a 0.110 mol/dm³ sodium hydroxide solution. The equation for the reaction is



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

Question 4

A student titrated 25.0 cm^3 portions of dilute sulfuric acid with a 0.110 mol/dm^3 sodium hydroxide solution. The equation for the reaction is

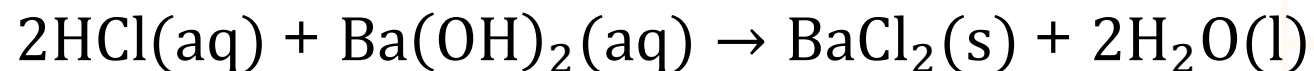


22.15 cm^3 of sodium hydroxide was needed. Calculate the concentration of the sulfuric acid in mol/dm^3 .

	H_2SO_4	NaOH
Concentration (mol/dm^3)		0.110
Volume (cm^3)	25.0	22.15
Moles		
Ratio	1	2

Question 5

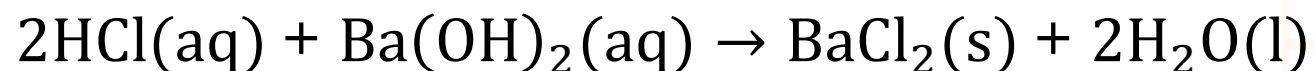
Barium chloride can be made by adding barium hydroxide solution to dilute hydrochloric acid. The balanced chemical equation for the reaction is:



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

Question 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 reacted with 15.0 cm³ of barium hydroxide. Calculate the concentration of the barium hydroxide.

	HCl	Ba(OH ₂)
Concentration (mol/dm ³)	1.0	
Volume (cm ³)	25.0	15.0
Moles		
Ratio	2	1

Worked answers

1. 0.44 mol/dm³

	CH₃COOH	NaOH
Concentration (mol/dm ³)	0.44	0.22
Volume (cm ³)	12.50	25.00
Moles	5.5×10^{-3}	5.5×10^{-3}
Ratio	1	1

$$n = \frac{cV}{1000} = \frac{0.22 \times 25.0}{1000} = 5.5 \times 10^{-3}$$

$$c = \frac{1000n}{V} = \frac{1000 \times 5.5 \times 10^{-3}}{12.50} = 0.44$$

Worked answers

2. 1.67 mol/dm³

	HNO ₃	KOH
Concentration (mol/dm ³)	2.0	1.67
Volume (cm ³)	12.50	25.00
Moles	0.05	0.05
Ratio	1	1

$$n(\text{HNO}_3) = \frac{cV}{1000} = \frac{2.0 \times 12.50}{1000} = 0.05$$

$$c(\text{KOH}) = \frac{1000n}{V} = \frac{1000 \times 0.05}{25.00} = 1.67$$

Worked answers

3. 1.38 mol/dm³

	Ba(OH₂)	H₂SO₄
Concentration (mol/dm ³)	1.38	0.55
Volume (cm ³)	10.0	25.00
Moles	0.01375	0.01375
Ratio	1	1

$$n = \frac{cV}{1000} = \frac{0.55 \times 25.0}{1000} = 0.01375$$

$$c = \frac{1000n}{V} = \frac{1000 \times 0.01375}{25.0} = 1.38$$

Worked answers

4. 0.049 mol/dm³

	H₂SO₄	NaOH
Concentration (mol/dm ³)	0.049	0.110
Volume (cm ³)	25.0	22.15
Moles	1.22 × 10⁻³	2.44 × 10⁻³
Ratio	1	2

$$n = \frac{cV}{1000} = \frac{0.110 \times 22.15}{1000} = 2.44 \times 10^{-3}$$

$$c = \frac{1000n}{V} = \frac{1000 \times 1.22 \times 10^{-3}}{25.0} = 0.049$$

Worked answers

5. 0.83 mol/dm³

	HCl	Ba(OH ₂)
Concentration (mol/dm ³)	1.0	0.83
Volume (cm ³)	25.0	15.00
Moles	0.025	0.0125
Ratio	2	1

$$n(\text{HCl}) = \frac{cV}{1000} = \frac{1.0 \times 25.0}{1000} = 0.025$$

$$c(\text{Ba(OH}_2)) = \frac{1000n}{V} = \frac{1000 \times 0.0125}{15.00} = 0.83$$