AQA Chemistry GCSE

C4.7

Student required practical 2

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Carrying out a titration – Aiming for grade 8

Specification references:

- C4.2.5
- WS 2.4, 2.6, MS 1a, 1c, 2a
- AT 1, 8
- **Required practical activity 2:** Determination of the reacting volumes of solutions of a strong acid and a strong alkali by titration

Aims

In this activity you will carry out a titration to find the exact volume of an acid (hydrochloric acid) needed to neutralise a measured volume of an alkali (sodium hydroxide).

Learning outcomes

After completing this activity, you should be able to:

- accurately read the volume on a burette to 1 decimal place
- identify concordant results
- calculate a titre
- describe how an indicator can be used to determine the end point
- explain how accuracy can be improved in a titration
- carry out a titration between hydrochloric acid and sodium hydroxide
- recall the main steps involved in the practical procedure
- justify the use of a pipette and burette for a titration, evaluating the errors involved in reading these instruments
- explain how precise results are obtained in a titration
- justify the use of an indicator in an acid–base titration
- calculate the concentration of sodium hydroxide in mol/dm^3 and in g/dm^3 (H).

Safety

- Eye protection
- 0.100 mol/dm^3 hydrochloric acid: IRRITANT
- Sodium hydroxide solution: IRRITANT

Equipment

- 50 cm^3 burette plus stand and burette holder
- 2 × 250 cm^3 beaker
- 250 cm^3 conical flask
- 25.0 cm^3 bulb pipette plus pipette filler
- funnel
- phenolphthalein indicator
- 0.100 mol/dm^3 hydrochloric acid
- sodium hydroxide of unknown concentration

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- white tile
- wash bottle of distilled water

Setting the scene

A titration is a technique used to find the exact volumes of acid and alkali that react together. The point at which the acid and alkali have reacted completely is called the **end point** of the reaction. We judge when this point is reached by using an indicator which changes colour at the end point.

The equation for the reaction is:

$$HCl(aq) + NaOH(aq) \rightarrow NaCl(aq) + H_2O(l)$$

The indicator used in this titration is phenolphthalein: it is colourless in acid and pink in alkali.

The concentration of sodium hydroxide in mol/dm^3 and g/dm^3 can then be calculated from the reacting volumes and the known concentration of the hydrochloric acid.

Method

1. Collect some hydrochloric acid in a beaker and label it.
2. Rinse your burette with distilled water and then with some of the hydrochloric acid.
3. Fill a burette with the hydrochloric acid beyond the zero mark and then let the solution run out until the bottom of the meniscus is exactly on the zero mark. All bubbles should be removed from the jet.
4. Collect some sodium hydroxide in another beaker and label it.
5. Rinse the 25.0 cm^3 pipette with distilled water and then with the sodium hydroxide.
6. Use the pipette and the pipette filler to transfer 25.0 cm^3 of the sodium hydroxide into a clean dry conical flask.
7. Add three to four drops of phenolphthalein indicator into the flask and swirl. Place the conical flask on the white tile directly below the burette.
8. Record the initial burette reading in the table below (this should be 0.00 cm^3).
9. Carry out a rough titration by adding the acid to the alkali in small amounts at a time. Swirl the flask after every addition and continue until the indicator changes from pink to colourless. Note the final burette reading and record it in the table. ***Your teacher will show you how to read the burette.***
10. Repeat the titration accurately by adding the acid drop-wise near the end point. Make sure you record the initial and final burette readings in the appropriate column in the table.
11. Repeat the accurate titrations until you have two concordant results (within 0.10 cm^3 of each other).
12. Record all your readings in the table below.

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Results

	Rough	Accurate			
		1	2	3	4
final burette reading cm^3					
initial burette reading cm^3					
volume of HCl added cm^3					

Questions

1 Place a star against the concordant titres in your results table and use them to calculate the average volume of HCl added. This is your **mean titre**. (*2 marks*)

2 Complete the following sentence:

25.0 cm^3 of sodium hydroxide was neutralised by ____ cm^3 of 0.100 mol/dm^3 hydrochloric acid (*1 mark*)

3 Use the following steps to find the concentration of the sodium hydroxide.

You will need to know that:

- $\text{No. of moles} = \frac{\text{Concentration (mol/dm}^3\text{)} \times \text{Volume (in cm}^3\text{)}}{1000}$
- Concentration in g/dm^3 = Concentration in $mol/dm^3 \times M_r$

STEP 1

Calculate the number of moles of HCl in your mean titre (*1 mark*)

STEP 2

From the balanced equation, state the number moles of NaOH in 25 cm^3 (*1 mark*)

STEP 3

Calculate the concentration of NaOH in mol/dm^3 (*1 mark*)

STEP 4

Calculate the M_r of NaOH (A_r values: H = 1, O = 16, Na = 23) (*1 mark*)

STEP 5

Calculate the concentration of NaOH in g/dm^3 (*1 mark*)

4 **a** Draw a pictorial flow chart to show the titration procedure. Label each piece of apparatus and the chemicals involved. (*6 marks*)

b State what is meant by the ***end point.*** (*1 mark*)

c Describe the colour change you would observe if methyl orange had been used as the indictor rather than phenolphthalein. (*1 mark*)

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d Explain why universal indicator is not a suitable indicator for a titration. (*2 marks*)

e The titration method is designed to give very accurate results. State four steps in the method which help to ensure accuracy. (*4 marks*)

Student follow-up

1 a A student used a pipette to add 25.0 cm^3 of 0.1 mol/dm^3 sodium hydroxide to a conical flask.

The student carried out a titration to find out the volume of sulfuric acid needed to neutralise the sodium hydroxide.

Describe how the student would complete the titration.

You should name a suitable indicator and give the colour change that would be seen. (*4 marks*)

b The student carried out three titrations. The results are shown below:

	Titration 1	Titration 2	Titration 3
volume of sulfuric acid in cm^3	27.90	27.65	27.75

Use the student's concordant results (those within 0.10 cm^3 of each other) to work out the mean volume of sulfuric acid added. (*1 mark*)

c The equation for the reaction is: $2NaOH + H_2SO_4 \rightarrow Na_2SO_4 + 2H_2O$

Use the steps in Question 3 to calculate the concentration of the sulfuric acid in mol/dm^3. Give your answer to 3 significant figures. (*3 marks*)

d Calculate the M_r of sulfuric acid and use it to work out the concentration of the acid in g/dm^3 (A_r values: H = 1, O = 16, S = 32). (*2 marks*)