2 A student investigates the reaction between dilute hydrochloric acid and aqueous sodium hydroxide.

The student does five experiments.

Experiment 1

- Fill a burette with aqueous sodium hydroxide.
- Run some of the aqueous sodium hydroxide out of the burette so that the level of the aqueous sodium hydroxide is on the burette scale.
- Record the initial burette reading.
- Use a volumetric pipette to add 25.0 cm^3 of dilute hydrochloric acid to a conical flask.
- Stand the conical flask on a white tile.
- Add five drops of thymolphthalein indicator to the conical flask.
- Slowly add aqueous sodium hydroxide from the burette to the conical flask, while swirling the flask, until the solution just changes colour. This is the end-point.
- Record the final burette reading.

Experiment 2

- Empty the conical flask and rinse it with distilled water.
- Refill the burette with aqueous sodium hydroxide.
- Run some of the aqueous sodium hydroxide out of the burette so that the level of the aqueous sodium hydroxide is on the burette scale.
- Record the initial burette reading.
- Use the volumetric pipette to add 25.0 cm^3 of dilute hydrochloric acid to the conical flask.
- Add 0.25 g of sodium hydrogencarbonate to the conical flask and swirl the flask.
- Stand the conical flask on the white tile.
- Add five drops of thymolphthalein indicator to the conical flask.
- Slowly add aqueous sodium hydroxide from the burette to the conical flask, while swirling the flask, until the solution just changes colour. This is the end-point.
- Record the final burette reading.

Experiment 3

- Repeat Experiment 2 using 0.50 g of sodium hydrogencarbonate instead of 0.25 g.

Experiment 4

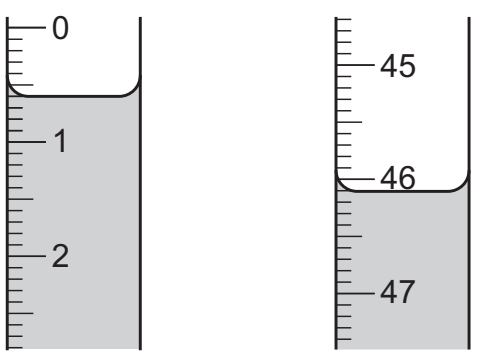
- Repeat Experiment 2 using 1.00 g of sodium hydrogencarbonate instead of 0.25 g.

Experiment 5

- Repeat Experiment 2 using 1.50 g of sodium hydrogencarbonate instead of 0.25 g.

(a) Use the information in the descriptions of Experiments 1 to 5 and the burette diagrams in Fig. 2.1 and Fig. 2.2 to complete Table 2.1.

Experiment 1

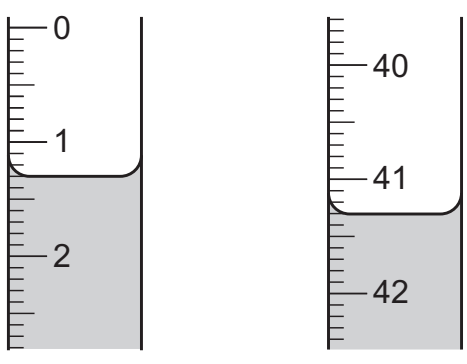


initial burette reading

final burette reading

Fig. 2.1

Experiment 2



initial burette reading

final burette reading

Fig. 2.2

Table 2.1

	Experiment 1	Experiment 2	Experiment 3	Experiment 4	Experiment 5
volume of dilute hydrochloric acid / cm^3					
mass of sodium hydrogencarbonate / g	0.00	0.25	0.50	1.00	1.50
final burette reading / cm^3			36.0	24.1	13.5
initial burette reading / cm^3			1.4	0.3	0.5
volume of aqueous sodium hydroxide added to reach the end-point / cm^3					13.0

[5]

(b) Complete a suitable scale on the *y*-axis and plot the results from Experiments 1 to 5 in Table 2.1 on Fig. 2.3. Draw a straight line of best fit.

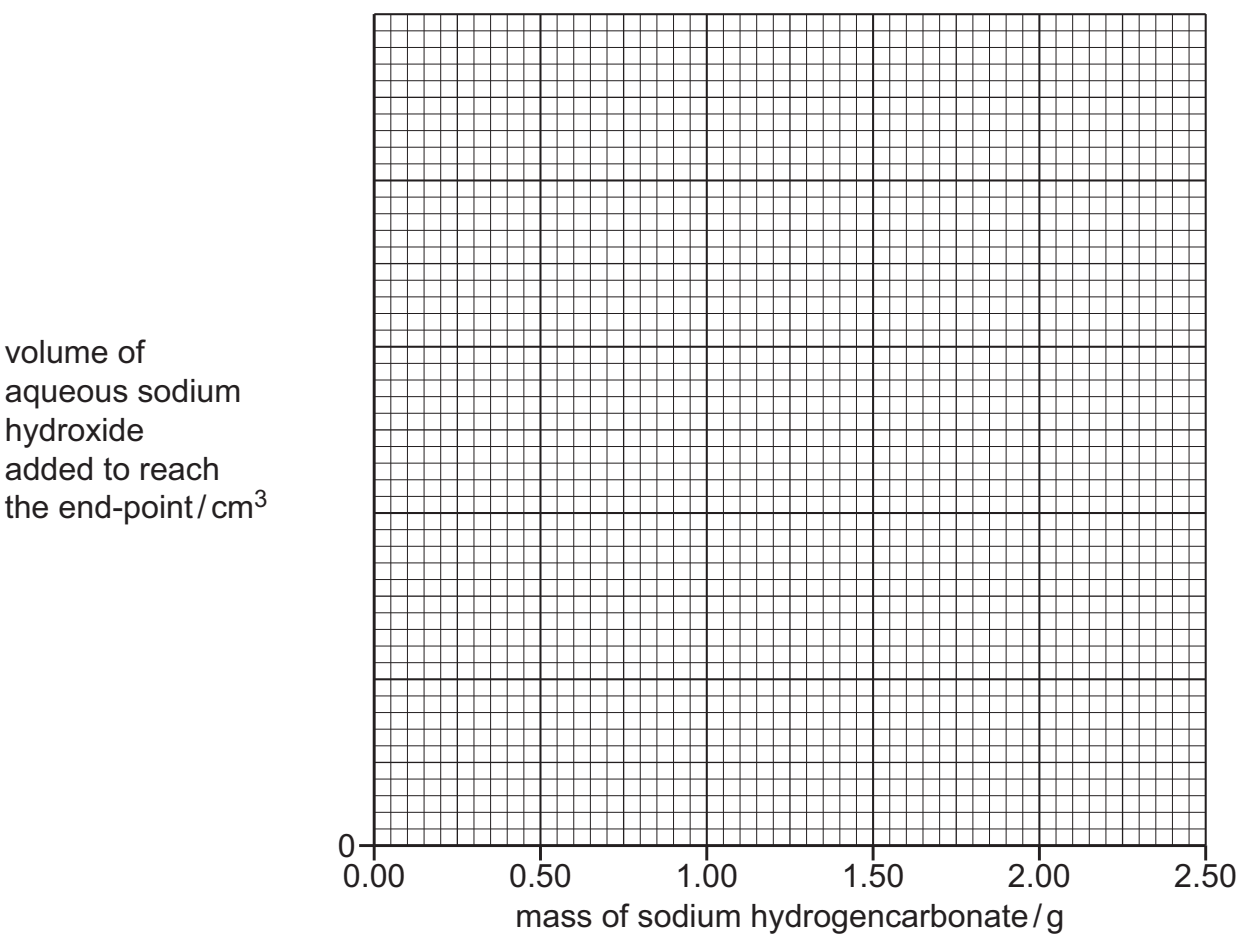


Fig. 2.3

[4]

(c) The sodium hydrogencarbonate added in Experiments 2 to 5 neutralises some of the dilute hydrochloric acid in the conical flask. The sodium hydroxide used in the titration neutralises the remaining dilute hydrochloric acid.

Extrapolate the line on your graph in Fig. 2.3 and deduce the mass of sodium hydrogencarbonate needed to neutralise **all** of the dilute hydrochloric acid in the conical flask.

Show clearly **on Fig. 2.3** how you worked out your answer.

mass of sodium hydrogencarbonate = ...
[3]

(d) **(i)** Explain why a volumetric pipette is used rather than a measuring cylinder to measure the volume of dilute hydrochloric acid used in each experiment.

.....

..... [1]

(ii) Explain why it is **not** possible to use a volumetric pipette instead of the burette to measure the volume of aqueous sodium hydroxide added in each experiment.

.....

..... [1]

(e) The conical flask is placed on a white tile to make the colour change of the indicator at the end-point more visible.

Explain why universal indicator is **not** a suitable indicator for this titration.

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..... [2]

(f) Draw a line **on Fig. 2.3** to show the results you would expect if the investigation was repeated using aqueous sodium hydroxide with twice the concentration.

Label your line **F**. [2]

[Total: 18]