1 You are going to investigate the temperature decrease when sodium hydrogencarbonate reacts with dilute hydrochloric acid.

Read all of the instructions carefully before starting the experiments.

Instructions
You are going to do six experiments.

(a) *Experiment 1*

- Use a measuring cylinder to pour 25 cm^3 of dilute hydrochloric acid into a conical flask.
- Use a thermometer to measure the initial temperature of the acid. Record the initial temperature in the table.
- Add the 1 g sample of sodium hydrogencarbonate to the conical flask. At the same time start the stop-clock.
- Continually stir the acid and sodium hydrogencarbonate mixture in the conical flask using the thermometer.
- Measure the temperature reached by the mixture after 1 minute. Record the temperature of the mixture in the table.
- Calculate and record the temperature decrease in the table.
- Rinse the conical flask with distilled water.

Experiment 2

- Repeat Experiment 1 using 2 g of sodium hydrogencarbonate instead of 1 g.

Experiment 3

- Repeat Experiment 1 using 3 g of sodium hydrogencarbonate instead of 1 g.

Experiment 4

- Repeat Experiment 1 using 5 g of sodium hydrogencarbonate instead of 1 g.

Experiment 5

- Repeat Experiment 1 using 6 g of sodium hydrogencarbonate instead of 1 g.

Experiment 6

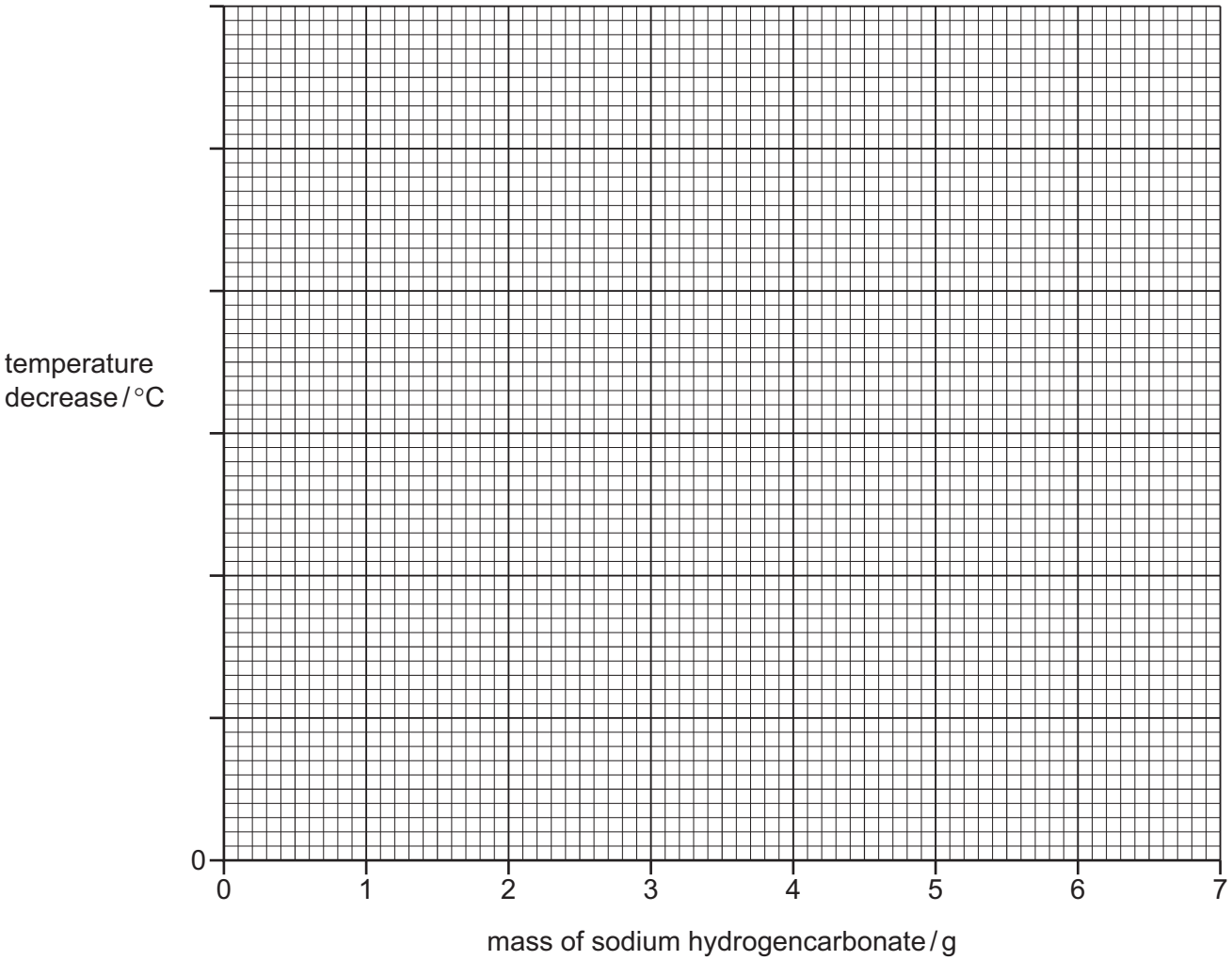
- Repeat Experiment 1 using 7 g of sodium hydrogencarbonate instead of 1 g.

experiment	mass of sodium hydrogencarbonate / g	initial temperature / °C	temperature after 1 minute / °C	temperature decrease / °C
1	1			
2	2			
3	3			
4	5			
5	6			
6	7			

[4]

(b) Complete a suitable scale on the *y*-axis and plot your results from Experiments 1 to 6 on the grid.

Draw **two** best-fit straight lines through your points. The first straight line should be for the first three points and must pass through (0,0). The second straight line should be for the last three points and must be horizontal. Extend your straight lines so that they meet each other.



[5]

(c) (i) **From your graph**, determine the temperature decrease and mass of sodium hydrogencarbonate where your two straight lines meet. Include appropriate units in your answer.

Show clearly **on the grid** how you worked out your answer.

temperature decrease = ...

mass of sodium hydrogencarbonate = ...

[3]

(ii) Explain why the temperature decrease becomes constant for high masses of sodium hydrogencarbonate.

.....

..... [1]

[Turn over

(d) The investigation could be repeated with dilute hydrochloric acid of half the concentration, but the same volume.

Sketch **on the grid** the graph you would expect to obtain.

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

(e) Suggest **two** changes that could be made to the apparatus that would improve the accuracy of the results. For each change explain why it would improve the accuracy of the results.

change 1 .....

explanation 1 .....

.....

change 2 .....

explanation 2 .....

.....

[4]

[Total: 19]

2 You are provided with one solid, solid **E**, and one solution, solution **F**.
Do the following tests on the substances, recording all of your observations at each stage.

tests on solid E

(a) Place about half of solid **E** in a hard-glass test-tube. Heat the solid gently for about 30 seconds.
Record your observations.

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..... [2]

Transfer the remaining solid **E** to a boiling tube. Add about 10 cm^3 of distilled water to the boiling tube.
Place a stopper in the boiling tube and shake the tube to dissolve solid **E** and form solution **E**.
Divide solution **E** into three approximately equal portions in two test-tubes and one boiling tube.

(b) To the first portion of solution **E** in a test-tube, add about 1 cm depth of dilute nitric acid followed by a few drops of aqueous barium nitrate.
Record your observations.

..... [1]

(c) To the second portion of solution **E** in a test-tube, add excess aqueous ammonia.
Record your observations.

..... [1]

(d) To the third portion of solution **E** in the boiling tube, add aqueous sodium hydroxide dropwise and then in excess.

Keep the product for use in (e).

Record your observations.

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..... [2]

(e) Gently warm the product from **(d)**. Test any gas produced.
Record your observations.

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..... [1]

[Turn over

(f) Identify the **three** ions contained in solid **E**.

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..... [3]

tests on solution F

(g) Carry out a flame test on solution **F**.
Record your observations.

..... [1]

(h) Divide the remaining solution **F** into two approximately equal portions in two test-tubes.

(i) To the first portion of solution **F** add a few drops of universal indicator solution.
Record your observations.

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..... [1]

(ii) To the second portion of solution **F** add approximately 2 cm depth of aqueous copper(II) sulfate.
Record your observations.

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..... [1]

(i) Identify solution **F**.

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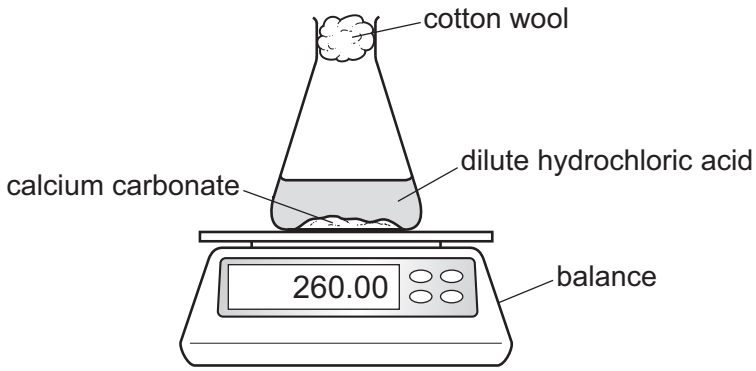
..... [2]

[Total: 15]

3 Dilute hydrochloric acid reacts with calcium carbonate to make carbon dioxide gas. The apparatus shown in the diagram can be used to follow the progress of the reaction. The carbon dioxide gas leaves the flask causing the mass shown on the balance to decrease.



Plan an investigation, using the apparatus shown in the diagram, to find out how the temperature of the dilute hydrochloric acid affects the rate of the reaction. Your plan should include how your results will show how the temperature of the dilute hydrochloric acid affects the rate of the reaction.

You are provided with dilute hydrochloric acid, calcium carbonate and common laboratory apparatus.

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..... [6]

Notes for use in qualitative analysis
Tests for anions

anion	test	test result
carbonate (CO_3^{2-})	add dilute acid	effervescence, carbon dioxide produced
chloride (Cl^-) [in solution]	acidify with dilute nitric acid, then add aqueous silver nitrate	white ppt.
bromide (Br^-) [in solution]	acidify with dilute nitric acid, then add aqueous silver nitrate	cream ppt.
iodide (I^-) [in solution]	acidify with dilute nitric acid, then add aqueous silver nitrate	yellow ppt.
nitrate (NO_3^-) [in solution]	add aqueous sodium hydroxide, then aluminium foil; warm carefully	ammonia produced
sulfate (SO_4^{2-}) [in solution]	acidify, then add aqueous barium nitrate	white ppt.
sulfite (SO_3^{2-})	add dilute hydrochloric acid, warm gently and test for the presence of sulfur dioxide	sulfur dioxide produced will turn acidified aqueous potassium manganate(VII) from purple to colourless

Tests for aqueous cations

cation	effect of aqueous sodium hydroxide	effect of aqueous ammonia
aluminium (Al^{3+})	white ppt., soluble in excess, giving a colourless solution	white ppt., insoluble in excess
ammonium (NH_4^+)	ammonia produced on warming	–
calcium (Ca^{2+})	white ppt., insoluble in excess	no ppt., or very slight white ppt.
chromium(III) (Cr^{3+})	green ppt., soluble in excess	grey-green ppt., insoluble in excess
copper(II) (Cu^{2+})	light blue ppt., insoluble in excess	light blue ppt., soluble in excess, giving a dark blue solution
iron(II) (Fe^{2+})	green ppt., insoluble in excess	green ppt., insoluble in excess
iron(III) (Fe^{3+})	red-brown ppt., insoluble in excess	red-brown ppt., insoluble in excess
zinc (Zn^{2+})	white ppt., soluble in excess, giving a colourless solution	white ppt., soluble in excess, giving a colourless solution

Tests for gases

gas	test and test result
ammonia (NH_3)	turns damp red litmus paper blue
carbon dioxide (CO_2)	turns limewater milky
chlorine (Cl_2)	bleaches damp litmus paper
hydrogen (H_2)	‘pops’ with a lighted splint
oxygen (O_2)	relights a glowing splint
sulfur dioxide (SO_2)	turns acidified aqueous potassium manganate(VII) from purple to colourless

Flame tests for metal ions

metal ion	flame colour
lithium (Li^+)	red
sodium (Na^+)	yellow
potassium (K^+)	lilac
copper(II) (Cu^{2+})	blue-green