Cambridge Assessment International Education

Graphing the rate of reaction between hydrochloric acid and calcium carbonate – Topic questions

The questions in this document have been compiled from a number of past papers, as indicated in the table below.

Use these questions to formatively assess your learners' understanding of this topic.

Question	Year	Series	Paper number
2(f)	2017	March	32
6(e)	2017	June	31
4(b)	2017	June	33
8(a)(b)(c)(d)	2018	June	33
7(d)	2017	November	31
7(a)(b)	2018	November	32
7(a)(b)(c)	2018	November	33
5	2017	June	41
7(a)	2017	November	41
5(c)	2018	November	41

The mark scheme for each question is provided at the end of the document.

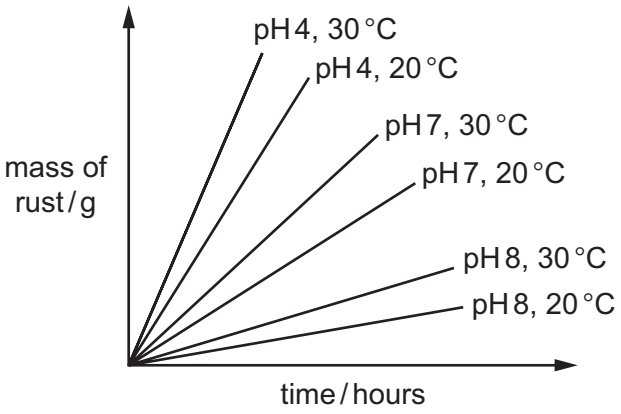
You can find the complete question papers and the complete mark schemes (with additional notes where available) on the School Support Hub at www.cambridgeinternational.org/support

(f) The rate of rusting of iron varies with pH and temperature.

(i) What **two** substances must be in contact with iron for it to rust?

..... [2]

(ii) The graph shows the rate of rusting at different pH values and temperatures.



How do pH and temperature affect the rate of rusting?

pH .....

temperature .....
[2]

(e) The table compares the time taken for reaction of an alloy with ethanoic acid, nitric acid and phosphoric acid, each at three different concentrations. The time taken for the alloy to decrease in mass by 1.0 g was measured. All other conditions were kept the same.

acid	time taken for reaction / hours		
	concentration of acid 0.04 mol / dm^3	concentration of acid 0.02 mol / dm^3	concentration of acid 0.01 mol / dm^3
ethanoic acid	92	190	410
nitric acid	2	6	18
phosphoric acid	19	39	80

(i) How does the concentration of acid affect the rate of reaction?

.....

..... [1]

(ii) Which acid reacts most rapidly with the alloy?

..... [1]

(iii) Predict how long it would take for the alloy to decrease in mass by 1.0 g using phosphoric acid of concentration 0.03 mol / dm^3.

time taken = ... hours [1]

(iv) Suggest which **one** of these pH values is the pH of concentrated aqueous ethanoic acid. Draw a circle around the correct answer.

pH 4 p

[1]

(b) Iron reacts with hydrochloric acid to form iron(II) chloride and a gas which 'pops' with a lighted splint.

(i) Identify this gas.

..... [1]

(ii) Suggest a practical method for investigating the rate of this reaction involving collection of the gas.
You may include a labelled diagram in your answer.

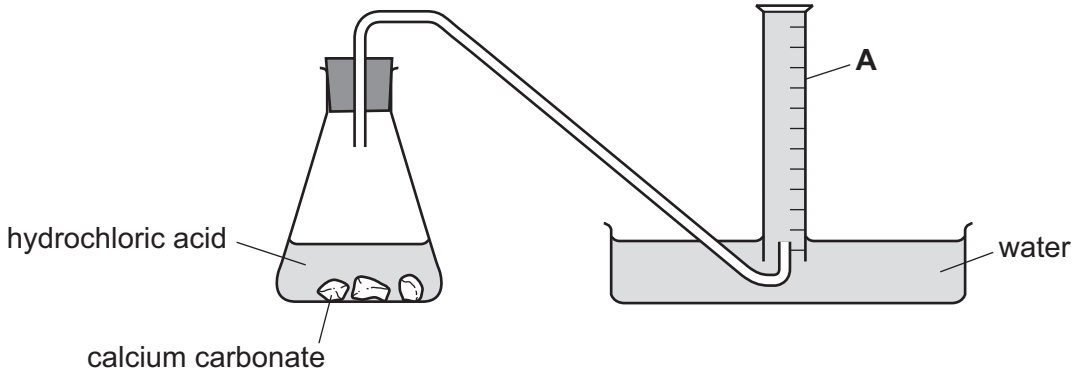
.....

.....

.....

..... [3]

8 The apparatus shown is used to investigate the rate of reaction between calcium carbonate and hydrochloric acid at 30 °C.



(a) Name the piece of apparatus labelled **A** in the diagram.

..... [1]

(b) Describe how this apparatus can be used to find the rate of reaction.

.....

.....

..... [2]

(c) The experiment is repeated at 20 °C. All other conditions are kept the same.

How does the decrease in temperature affect the rate of reaction?

..... [1]

(d) The experiment is repeated using the same mass of different size pieces of calcium carbonate. All other conditions are kept the same.

The sizes of the pieces of calcium carbonate are:
- large pieces
- small pieces
- powder

Complete the table by writing the sizes of the pieces in the first column.

size of the pieces of calcium carbonate	initial rate of reaction in cm^3 gas / s
	5
	2
	12

[1]

(d) Dilute hydrobromic acid reacts with magnesium ribbon.

(i) Suggest **three** ways of increasing the rate of this reaction.

1 .....

2 .....

3 .....

[3]

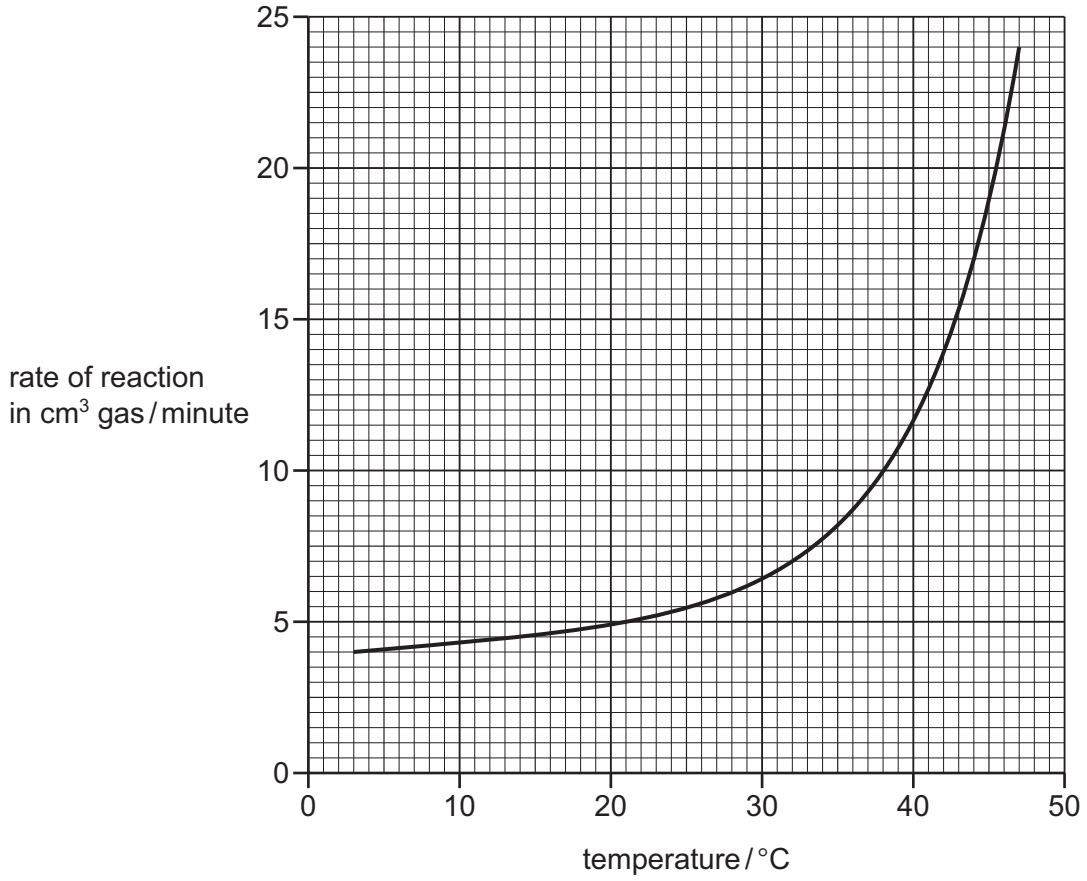
(ii) Hydrobromic acid reacts with oxygen. The products are water and bromine.

Balance the chemical equation for this reaction.

$$.....HBr + O_2 \rightarrow 2H_2O + 2Br_2$$

[1]

7 **(a)** The graph shows the effect of temperature on the rate of reaction of dilute hydrochloric acid with zinc powder.



(i) Determine the rate of reaction at 40 °C.

rate of reaction = ... cm^3 gas / minute [1]

(ii) The experiments were repeated using small lumps of zinc instead of zinc powder.
All other conditions were kept the same.

On the grid, draw a graph to show how the rate of reaction changes with temperature when small lumps of zinc are used instead of zinc powder. [2]

(b) What effects do these factors have on the rate of a chemical reaction?

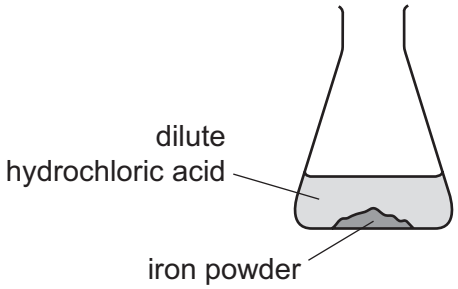
(i) decreasing the concentration of a reactant

..... [1]

(ii) adding a catalyst

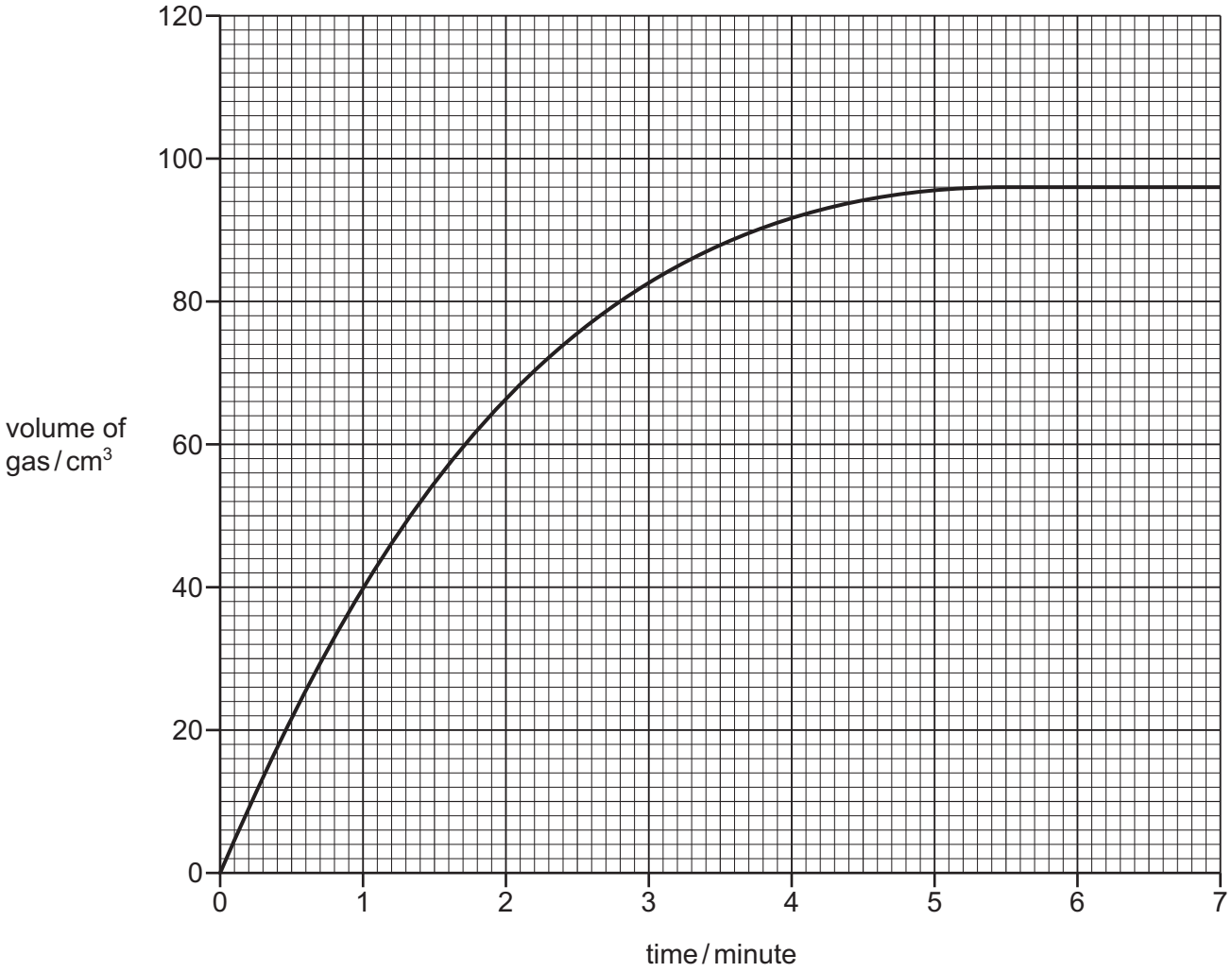
..... [1]

7 A student investigates the rate of reaction of iron powder with dilute hydrochloric acid.



(a) Complete the diagram to show the apparatus the student could use to collect and measure the gas produced.
Label your diagram. [3]

(b) The graph shows the results the student obtained using dilute hydrochloric acid of concentration 0.2 mol / dm^3 and an **excess** of iron powder.



Use the graph to deduce:

(i) the time that the reaction was complete

..... [1]

(ii) the volume of gas produced when the reaction was complete.

..... [1]

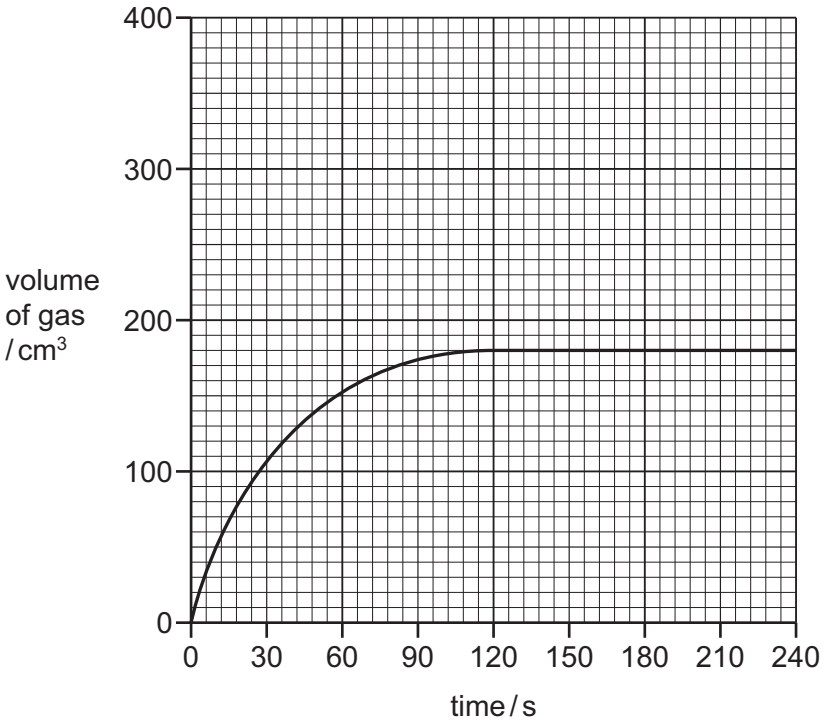
(c) The student repeated the experiment using a lower concentration of dilute hydrochloric acid. All other conditions were kept the same.

On the grid, draw a graph to show how the volume of gas changes with time when a lower concentration of dilute hydrochloric acid is used. [2]

5 When barium carbonate is added to dilute hydrochloric acid, carbon dioxide gas is formed.

A student carried out an experiment to measure the volume of gas formed as a reaction proceeds. The student added a small mass of powdered barium carbonate to an excess of 0.1 mol / dm^3 hydrochloric acid. A graph of the results was drawn.

The graph is shown.



(a) Name the **two** pieces of apparatus needed to take the measurements shown on the graph.

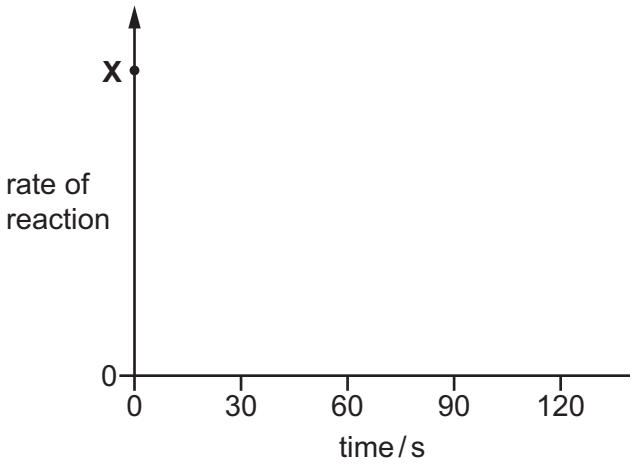
1 .....

2 .....

[1]

(b) On the axes below, sketch a graph to show how the rate of reaction changes as the reaction proceeds.

Assume the initial rate of reaction is represented by the point at **X**.



[2]

(c) The total volume of gas collected was 180 cm^3 at room temperature and pressure.

Calculate the mass, in grams, of barium carbonate used.

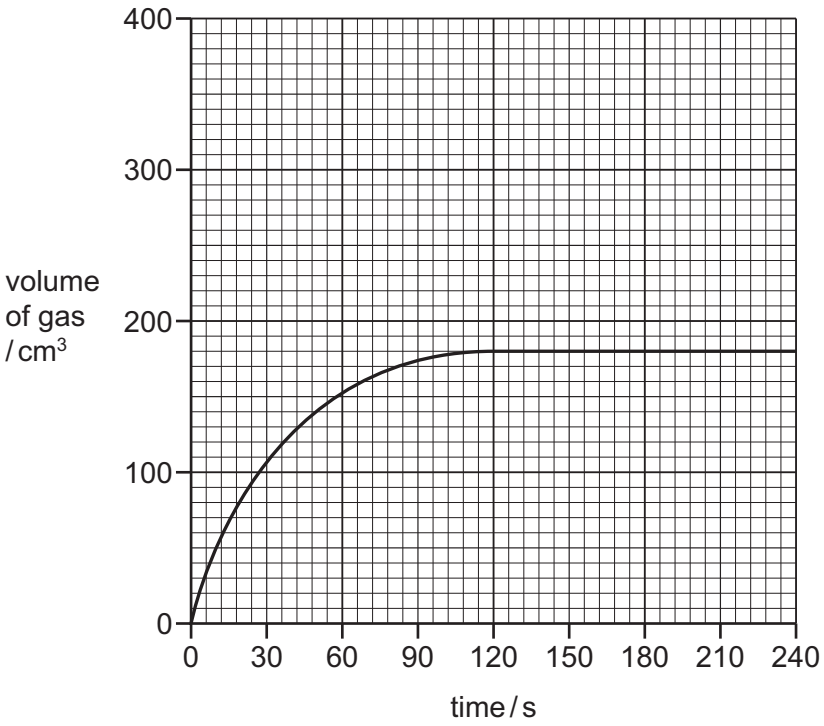
$$BaCO_3 + 2HCl \rightarrow BaCl_2 + H_2O + CO_2$$

mass of barium carbonate = ... g [3]

(d) The original graph has been drawn again.

On the grid, draw the graph expected if the same mass of barium carbonate is added as large lumps instead of as a powder. All other conditions are the same as in the original experiment.

Explain why your graph is different from the original graph.



.....

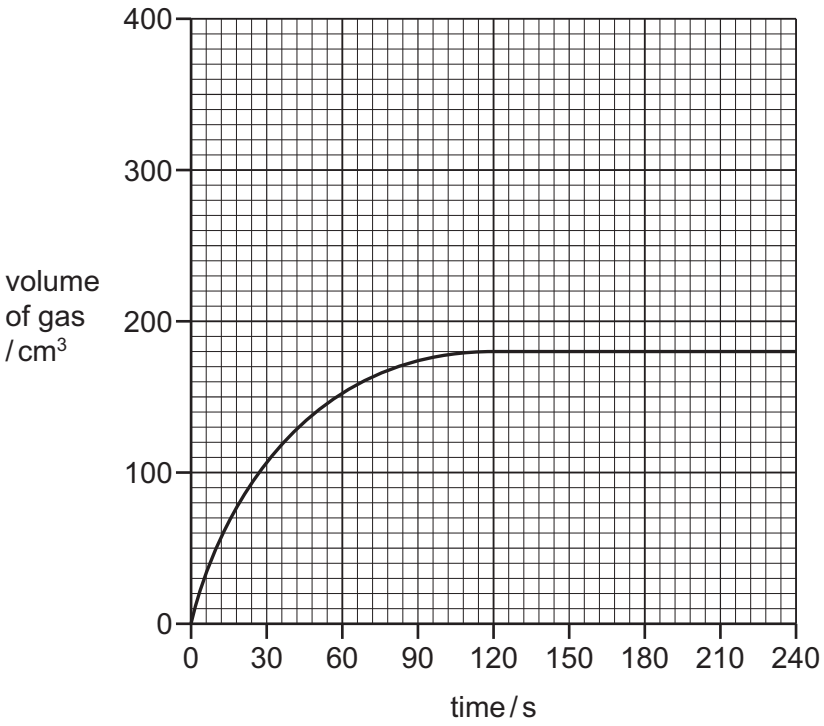
.....

..... [2]

(e) The original graph has been drawn again.

On the grid, draw the graph expected if the concentration of dilute hydrochloric acid is changed from 0.1 mol / dm^3 to 0.2 mol / dm^3. All other conditions are the same as in the original experiment.

Explain, in terms of particles, why your graph is different from the original graph.



.....

.....

.....

..... [4]

(f) The experiment is changed and the mass of powdered barium carbonate is doubled. All other conditions are the same as in the original experiment. The acid is still in excess.

Deduce the volume of gas formed at room temperature and pressure, in cm^3, in this experiment.

volume of gas = ... cm^3 [1]

[Total: 13]

7 Copper(II) oxide reacts with dilute hydrochloric acid.

$$CuO(s) + 2HCl(aq) \rightarrow CuCl_2(aq) + H_2O(l)$$

6.00 g of copper(II) oxide were added to 50.0 cm^3 of 1.00 mol / dm^3 hydrochloric acid. This was an excess of copper(II) oxide.

(a) The rate of the reaction can be increased by increasing the concentration of the hydrochloric acid or by heating it.

(i) In terms of collisions, explain why increasing the concentration of the hydrochloric acid increases the rate of the reaction.

.....

.....

.....

..... [2]

(ii) In terms of collisions, explain why heating the hydrochloric acid increases the rate of the reaction.

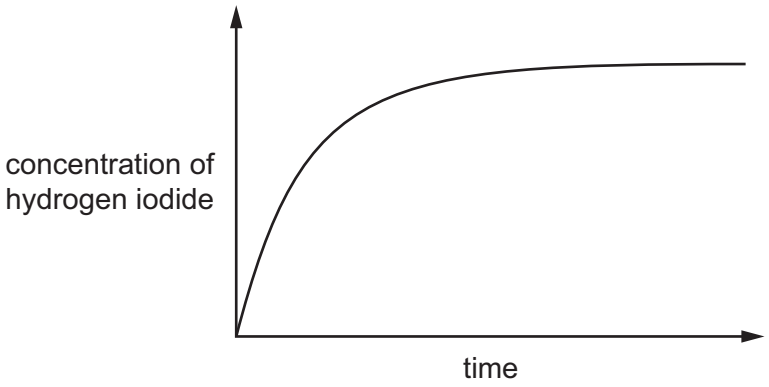
.....

.....

.....

..... [2]

(c) The graph shows how the concentration of hydrogen iodide, HI, changes after hydrogen gas and iodine gas are mixed together in a sealed container.



(i) When is the rate of reaction fastest?

..... [1]

(ii) The reaction was repeated at the same temperature and pressure but in the presence of a catalyst.

Draw a graph on the same axes to show how the concentration of hydrogen iodide changes with time in the presence of a catalyst. [2]

Question	Answer	Marks
2(f)(i)	water	**1**
	oxygen / air	**1**
2(f)(ii)	the lower the pH, the greater the rate / it is faster at a lower pH	**1**
	the higher the temperature, the greater the rate / it is faster at a higher temperature	**1**

Question	Answer	Marks
6(e)(i)	the more concentrated the acid, the greater the rate **ORA**	**1**
6(e)(ii)	nitric (acid)	**1**
6(e)(iii)	any value between 19 and 39 hours (exclusive of these values)	**1**
6(e)(iv)	pH 4	**1**

Question	Answer	Marks
4(b)(i)	hydrogen / H_2	**1**
4(b)(ii)	gas syringe connected to flask **OR** this described in words	**1**
	closed apparatus / workable apparatus **OR** this described in words	**1**
	timer / stop-watch **OR** this described in words	**1**

Question	Answer	Marks
8(a)	measuring cylinder	**1**
8(b)	measure the volume of gas given off / measure volume of carbon dioxide produced **OR** measure time taken	**1**
	over a given time(s) **OR** to produce given volume(s) of gas	**1**
8(c)	decreases rate / decreases it / makes it slower	**1**
8(d)	small pieces **AND** large pieces **AND** powder	**1**

Question	Answer	Marks
7(d)(i)	increasing the concentration of the acid	**1**
	increasing the temperature	**1**
	using magnesium powder / using smaller pieces of magnesium	**1**
7(d)(ii)	4 (HBr)	**1**

Question	Answer	Marks
7(a)(i)	11.5 (cm^3 / min)	**1**
7(a)(ii)	line in shape of upward curve (1) line below the curve for all temperatures (1)	**2**
7(b)(i)	decreases (rate) (1)	**1**
7(b)(ii)	increases (rate) (1)	**1**

Question	Answer	Marks
7(a)	gas syringe drawn / measuring vessel dipping into trough of water drawn (1) gas syringe or measuring cylinder correctly labelled (1) workable apparatus e.g. airtight (1)	**3**
7(b)(i)	any value between 5.0 and 5.5 min (inclusive)	**1**
7(b)(ii)	96 cm^3	**1**
7(c)	initial gradient of line less steep and starting at 0–0 (1) levelling off at a lower volume (1)	**2**

Question	Answer	Marks
5(a)	(stop-) watch **AND** syringe	**1**
5(b)	graph starts at **X** and is a curve with a decreasing gradient	**1**
	graph hits zero rate at 114 ± 6 seconds	**1**
5(c)	**M1** moles of carbon dioxide = 180 / 24 000 = 0.0075	**1**
	M2 molar mass of barium carbonate = 197	**1**
	M3 mass of barium carbonate = **M1** × **M2** = 1.48 (g)	**1**
5(d)	curve starts from (0,0) and has a lower gradient than the original curve	**1**
	because lumps have a lower surface area	**1**
5(e)	curve starts from (0,0) and has a steeper gradient than the original curve	**1**
	finishes at the same volume of gas	**1**
	because there are more particles per unit volume / dm^3 / cm^3	**1**
	because there are more collisions per second / unit time **OR** a greater collision rate	**1**
5(f)	(cm^3)	**1**

Question	Answer	Marks
7(a)(i)	more particles (of acid) in a given volume / dm^3 / cm^3	**1**
	more collisions per second / unit time **OR** greater collision rate	**1**
7(a)(ii)	particles have more energy / particles move faster / more collisions per second / more collisions per unit time / greater collision rate	**1**
	more (of the) particles / collisions have energy greater than the activation energy / more particles have sufficient energy to react / more collisions have sufficient energy to react / a greater percentage of collisions are successful	**1**

Question	Answer	Marks
5(c)(i)	at the start / beginning	**1**
5(c)(ii)	**M1** new line is steeper than printed line and starts at origin	**1**
	M2 new line reaches same final volume as printed line	**1**