Paper 3

Questions are applicable for both core and extended candidates

1 Samarium is a metal.

(c) Large pieces of samarium react with cold water to produce hydrogen gas.

$$2Sm + 6H_2O \rightarrow 2Sm(OH)_3 + 3H_2$$

(i) Complete Fig. 5.1 by drawing the apparatus to show how the volume of hydrogen gas is measured during this reaction.

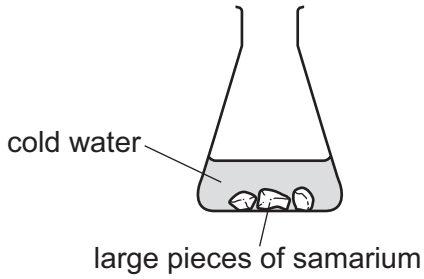


Fig. 5.1

[2]

(ii) The experiment is repeated using hot water instead of cold water.

All other conditions stay the same.

Describe how the rate of reaction changes when hot water is used.

..... [1]

(iii) The experiment is repeated using powdered samarium instead of large pieces of samarium.

All other conditions stay the same.

Describe how the rate of reaction changes when powdered samarium is used.

..... [1]

2 A student investigates the reaction of iron powder with dilute hydrochloric acid at 20 °C. The hydrochloric acid is in excess.

(a) Fig. 8.1 shows the volume of hydrogen gas released as the reaction proceeds.

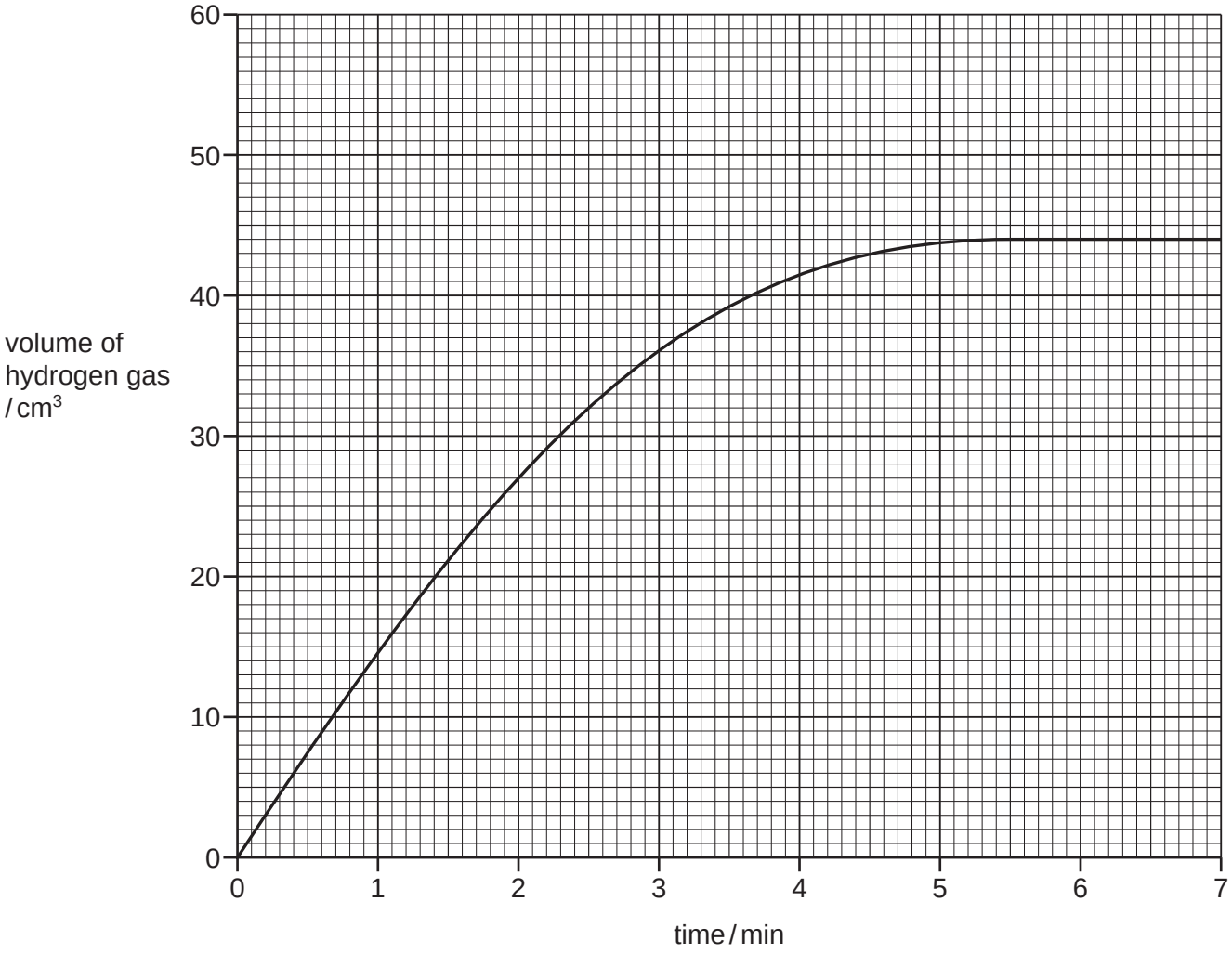


Fig. 8.1

(i) Deduce the volume of hydrogen gas released after 2 minutes.

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

(ii) The student repeats the experiment using dilute hydrochloric acid of a higher concentration.

All other conditions stay the same.

Draw a line on the grid in Fig. 8.1 to predict how the volume of hydrogen gas changes when dilute hydrochloric acid of a higher concentration is used. [2]

(b) (i) The student repeats the experiment with large pieces of iron.

All other conditions stay the same.

Describe how the rate of reaction differs when large pieces of iron are used.

..... [1]

(ii) The student repeats the experiment with iron powder at a temperature of 15 °C.

All other conditions stay the same.

Describe how the rate of reaction differs when a temperature of 15 °C is used.

..... [1]

3 **(a)** A student investigates the reaction of small pieces of zinc of the same mass and size with three different concentrations of dilute hydrochloric acid in the presence of a catalyst.

The three concentrations of dilute hydrochloric acid are:

- 1.0 mol / dm^3
- 1.5 mol / dm^3
- 2.0 mol / dm^3.

All other conditions stay the same.

Table 6.1 shows the time taken for each reaction to finish.

Table 6.1

concentration of hydrochloric acid in mol / dm^3	time taken for the reaction to finish in s
	200
	100
	150

(i) Complete Table 6.1 by writing the concentrations of hydrochloric acid in the first column. [1]

(ii) Describe the effect on the time taken for the zinc to finish reacting with 2.0 mol / dm^3 hydrochloric acid with no catalyst present.

All other conditions stay the same.

..... [1]

(iii) Describe the effect on the time taken for the zinc to finish reacting with 2.0 mol / dm^3 hydrochloric acid when the surface area of the zinc is increased.

All other conditions stay the same.

..... [1]

4 A student investigates the reaction of large pieces of magnesium carbonate with dilute hydrochloric acid at 20 °C. The magnesium carbonate is in excess.

(a) Fig. 6.1 shows the volume of carbon dioxide gas released as the reaction proceeds.

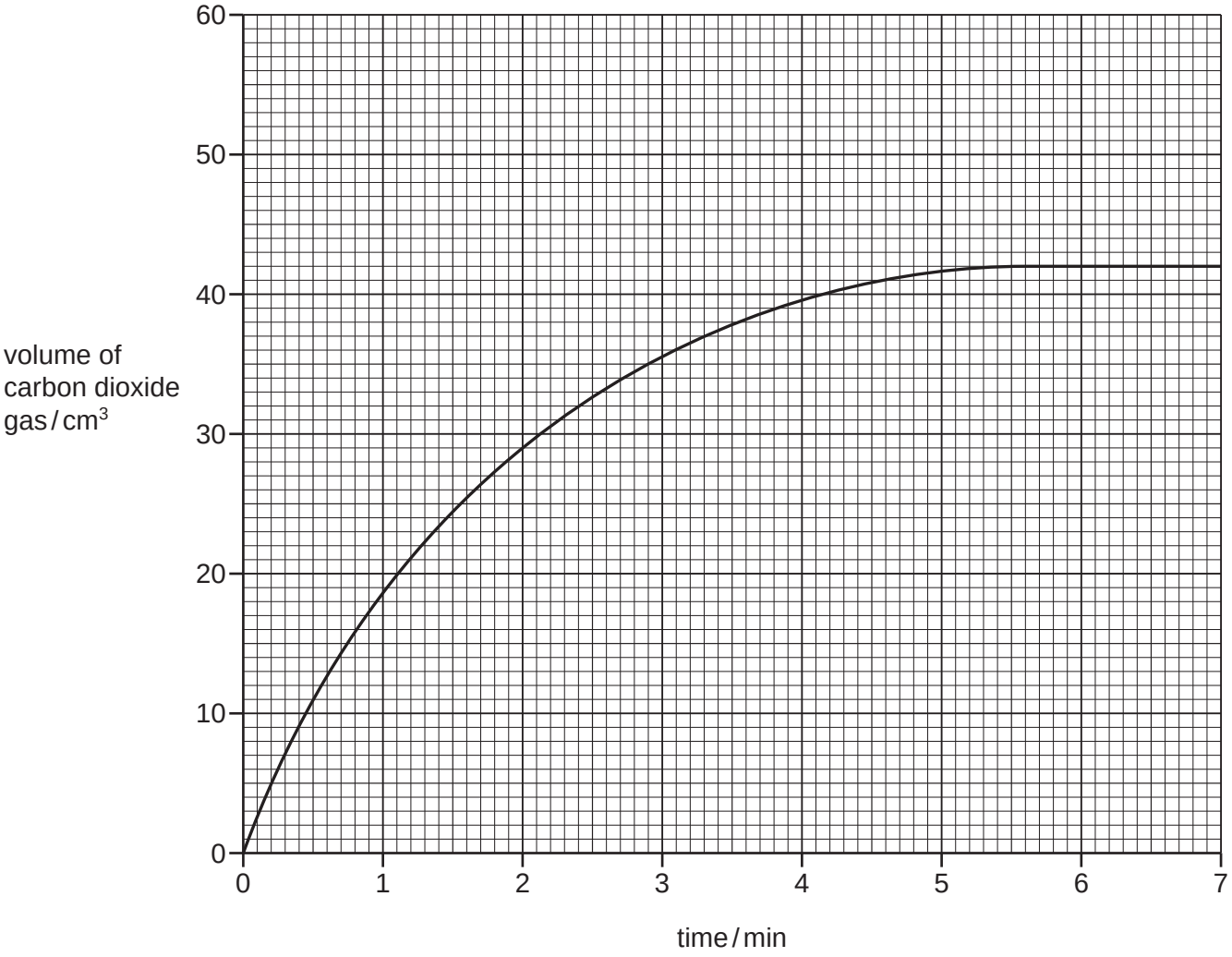


Fig. 6.1

(i) Deduce the volume of carbon dioxide gas released after 2 minutes.

volume of carbon dioxide = ... cm^3 [1]

(ii) The student repeats the experiment using the same volume of hydrochloric acid but with a higher concentration. The magnesium carbonate is still in excess.

All other conditions stay the same.

Draw a line on the grid in Fig. 6.1 to show the volume of carbon dioxide released when hydrochloric acid with a higher concentration is used. [2]

(b) (i) The student repeats the experiment using smaller pieces of magnesium carbonate.

All other conditions stay the same.

Describe how the rate of reaction differs when smaller pieces of magnesium carbonate are used.

..... [1]

(ii) The student repeats the experiment at 10 °C.

All other conditions stay the same.

Describe how the rate of reaction differs when the temperature is 10 °C.

..... [1]

(c) Hydrochloric acid reacts with iron.

Complete the word equation for this reaction.

hydrochloric acid	+	iron	→	....	+	.....

[2]

(d) Acids are used as catalysts in many chemical reactions.

State the meaning of the term catalyst.

.....

..... [2]

[Total: 9]

5 A student investigates the reaction of small pieces of zinc with dilute sulfuric acid at 20 °C. The zinc is in excess.

(a) Fig. 4.1 shows the volume of hydrogen gas released as the reaction proceeds.

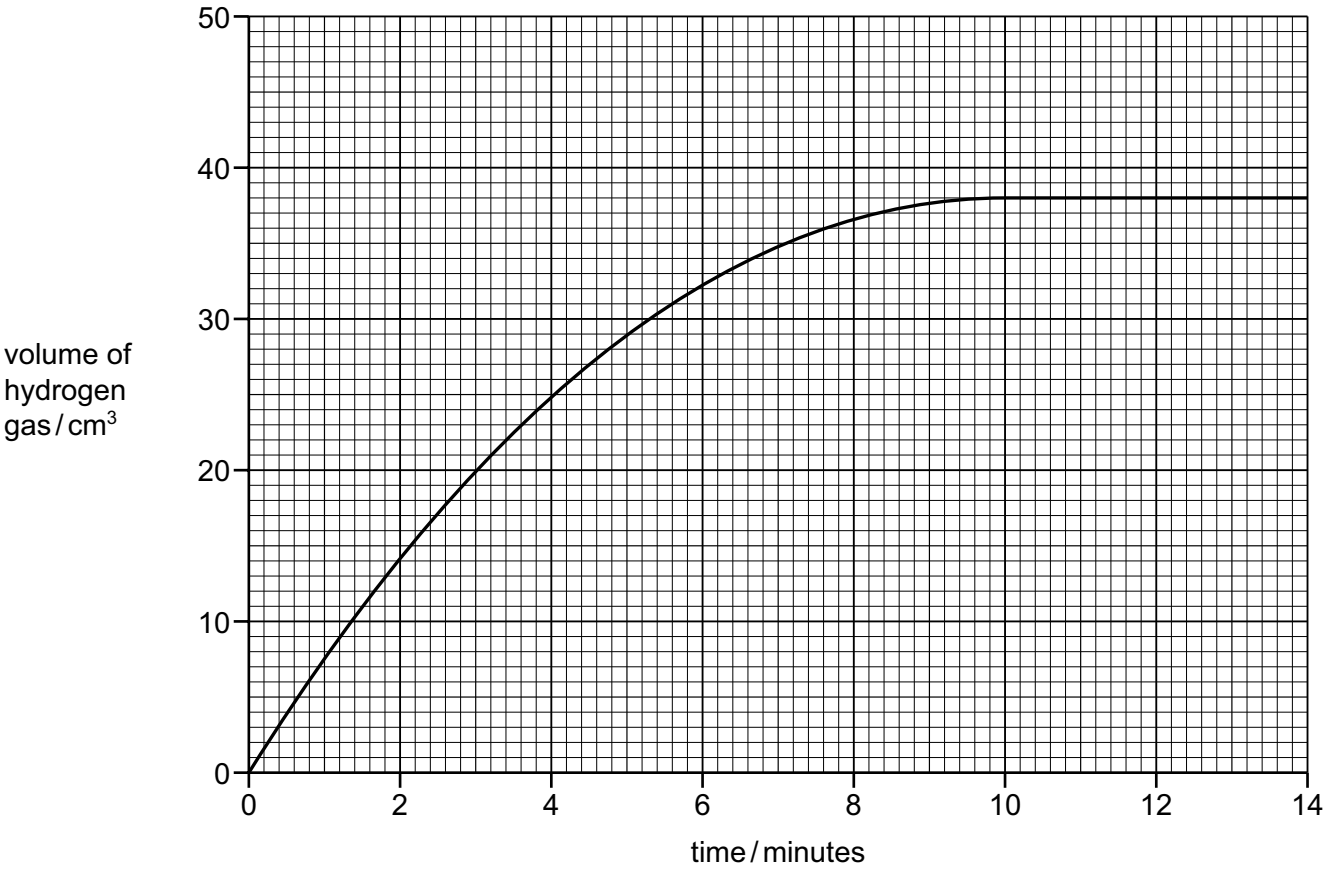


Fig. 4.1

(i) Suggest why the volume of hydrogen gas stays the same after 10 minutes.

.....

..... [1]

(ii) Deduce the time taken from the start of the experiment to collect 20 cm^3 of hydrogen gas.

..... [1]

(iii) The student repeats the experiment at 30 °C.

All other conditions stay the same.

Draw a line **on the grid** in Fig. 4.1 to show how the volume of hydrogen gas changes with time when the reaction is carried out at 30 °C. [2]

(b) The student repeats the experiment using zinc powder instead of small pieces of zinc.

Describe how the rate of reaction differs when zinc powder is used.

Give a reason for your answer.

.....

.....

..... [2]

6 This question is about acids, bases and salts.

(c) The rate of reaction of zinc powder with dilute sulfuric acid is found by measuring the increase in volume of hydrogen gas produced as time increases.

Describe the effect, if any, of each of the following on the rate of this reaction.

- The reaction is carried out with large pieces of zinc instead of zinc powder.

All other conditions stay the same.

.....

- The reaction is carried out using a catalyst.

All other conditions stay the same.

.....

- The reaction is carried out with dilute sulfuric acid of a lower concentration.

All other conditions stay the same.

.....

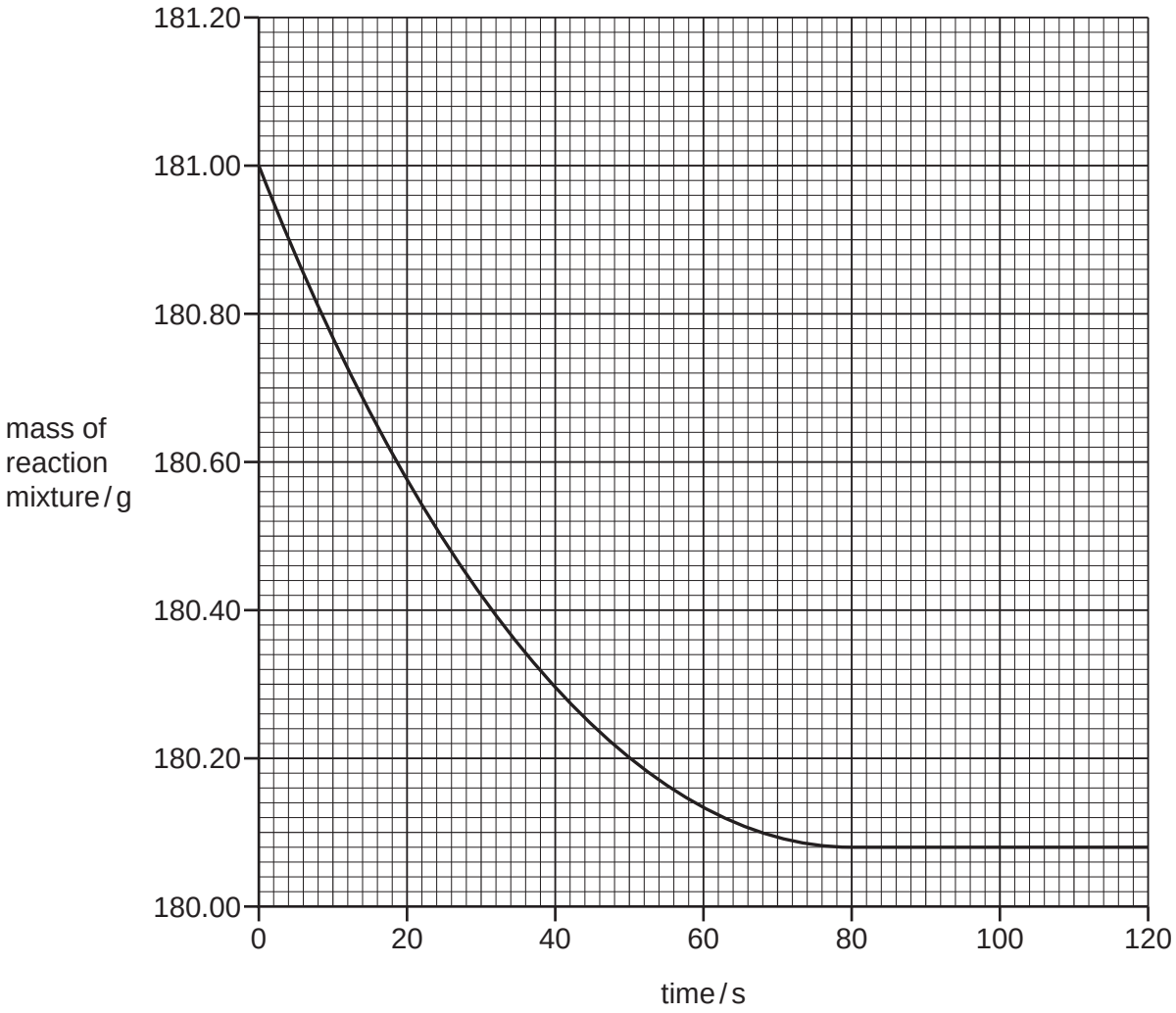
[3]

7 A student investigates the reaction of large pieces of copper(II) carbonate with dilute hydrochloric acid. The hydrochloric acid is in excess.

$$CuCO_3 + 2HCl \rightarrow CuCl_2 + CO_2 + H_2O$$

The rate of reaction is found by measuring the mass of the reaction mixture as time increases.

The results are shown on the graph.



(a) Deduce the mass of the reaction mixture at 30 s.

mass = ... g [1]

(b) The experiment is repeated using smaller pieces of copper(II) carbonate.

All other conditions stay the same.

Draw a line **on the grid** to show how the mass of the reaction mixture changes as time increases. [2]

(c) Describe the effect each of the following has on the rate of reaction of copper(II) carbonate with dilute hydrochloric acid.

All other conditions stay the same.

- The reaction is carried out in the presence of a catalyst.

.....

- The reaction is carried out using a lower concentration of hydrochloric acid.

.....

[2]

(d) When 0.2 g of copper(II) carbonate is used, 38 cm^3 of carbon dioxide gas is produced.

Calculate the volume of carbon dioxide gas produced when 0.50 g of copper(II) carbonate is used.

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

[Total: 6]

8 This question is about acids, bases and salts.

(b) (i) Small pieces of zinc react with excess hydrochloric acid of different concentrations. The time taken for each reaction to finish is recorded.

The concentrations of each acid are:

- 0.5 mol / dm^3
- 1.0 mol / dm^3
- 2.0 mol / dm^3.

All other conditions stay the same.

Complete the table by writing the concentrations in the first column.

concentration of acid in mol / dm^3	time taken for reaction to finish / s
	40
	20
	80

[1]

(ii) Describe the effect on the time taken for the reaction to finish when it is carried out at a lower temperature.

All other conditions stay the same.

..... [1]

Paper 4

Questions are applicable for both core and extended candidates unless indicated in the question

9 The Haber process is used to manufacture ammonia.

(b) The equation for the Haber process is shown.

$$N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g) \qquad \Delta H = -92\,kJ/mol$$

The reaction is reversible. The forward reaction is exothermic.

(v) Explain in terms of collision theory why increasing the temperature increases the rate of the reaction. **(extended only)**

.....

.....

.....

.....

..... [3]

10 Oxygen is produced by the decomposition of aqueous hydrogen peroxide. Manganese(IV) oxide, MnO_2, is a catalyst for this reaction.

(a) State the meaning of the term catalyst. **(extended only)**

.....

..... [2]

(b) A student adds powdered manganese(IV) oxide to aqueous hydrogen peroxide in a conical flask as shown in Fig. 4.1. The mass of the conical flask and its contents is measured at regular time intervals. The mass decreases as time increases.

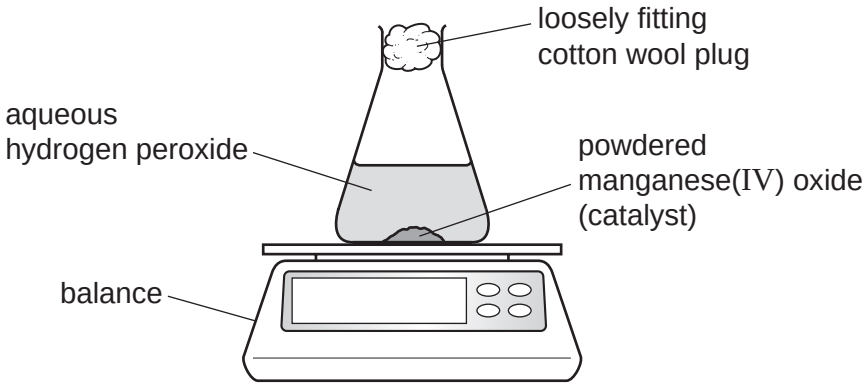


Fig. 4.1

(i) State why the mass of the conical flask and its contents decreases as time increases.

..... [1]

(ii) The rate of reaction is highest at the start of the reaction. The rate decreases and eventually becomes zero.

Explain why the rate of reaction is highest at the start of the reaction. **(extended only)**

.....

..... [1]

(iii) Explain why the rate of reaction eventually becomes zero. **(extended only)**

.....

..... [1]

(c) The experiment is repeated at an increased temperature.
All other conditions stay the same.

Explain in terms of collision theory why the rate of reaction is higher at an increased temperature.

(extended only)

.....

.....

.....

..... [3]

(d) The equation for the decomposition of aqueous hydrogen peroxide, $H_2O_2(aq)$, is shown.

$$2H_2O_2(aq) \rightarrow 2H_2O(l) + O_2(g)$$

50.0 cm^3 of a 0.200 mol/dm^3 solution of $H_2O_2(aq)$ is used.

Calculate the mass of O_2 that forms.
Use the following steps.

- Calculate the number of moles of H_2O_2 used.

..... mol

- Determine the number of moles of O_2 produced.

..... mol

- Calculate the mass of O_2 produced.

..... g
[3]

(e) State the effect on the mass of oxygen produced if the mass of powdered manganese(IV) oxide catalyst is increased.

..... [1]

(f) Oxygen can also be produced by the decomposition of mercury(II) oxide, HgO.
The only products of this decomposition are mercury and oxygen.

Write a symbol equation for this decomposition.

..... [2]

[Total: 14]

11 Aqueous hydrogen peroxide, H_2O_2, slowly forms water and oxygen at room temperature and pressure, r.t.p. This reaction is catalysed by manganese(IV) oxide.

The equation is shown.

$$2H_2O_2(aq) \rightarrow 2H_2O(l) + O_2(g)$$

(a) State the test for oxygen gas.

test .....

observations .....

[1]

(b) A student investigates the rate of formation of oxygen gas when manganese(IV) oxide is added to aqueous hydrogen peroxide.

The volume of oxygen gas formed is measured at regular time intervals at r.t.p. The results are plotted onto the graph in Fig. 4.1.

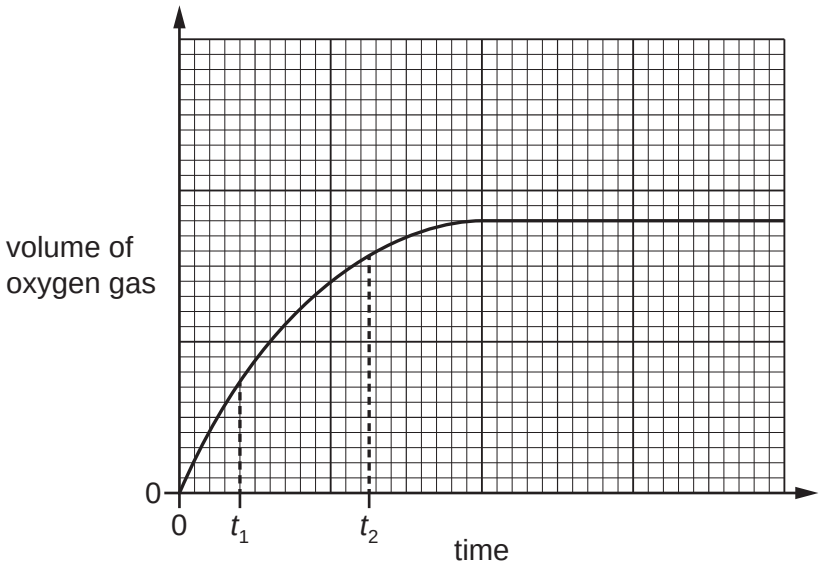


Fig. 4.1

(i) State how the graph in Fig. 4.1 shows the rate of reaction at time t_2, is lower than at time t_1.

..... [1]

(ii) Explain, using collision theory, why the rate of reaction at time t_2 is lower than at time t_1.

(extended only)

.....

..... [2]

(iii) On Fig. 4.1, sketch the graph obtained when the experiment is repeated using aqueous hydrogen peroxide at a higher temperature. All other conditions remain the same. [2]

12 A student investigates the progress of the reaction between dilute hydrochloric acid, HC*l*, and an excess of large pieces of marble, $CaCO_3$, using the apparatus shown in Fig. 5.1.

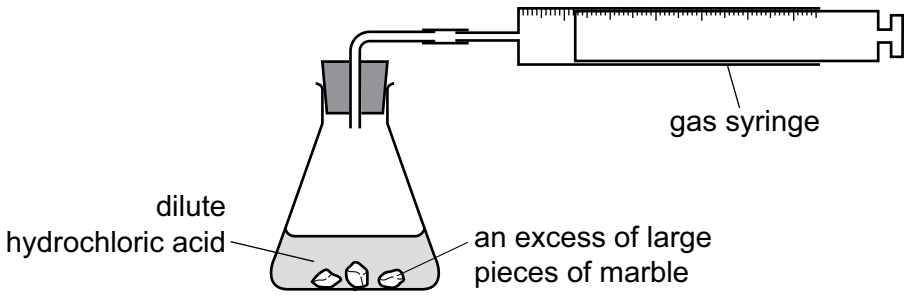


Fig. 5.1

(a) A graph of the volume of gas produced against time is shown in Fig. 5.2.

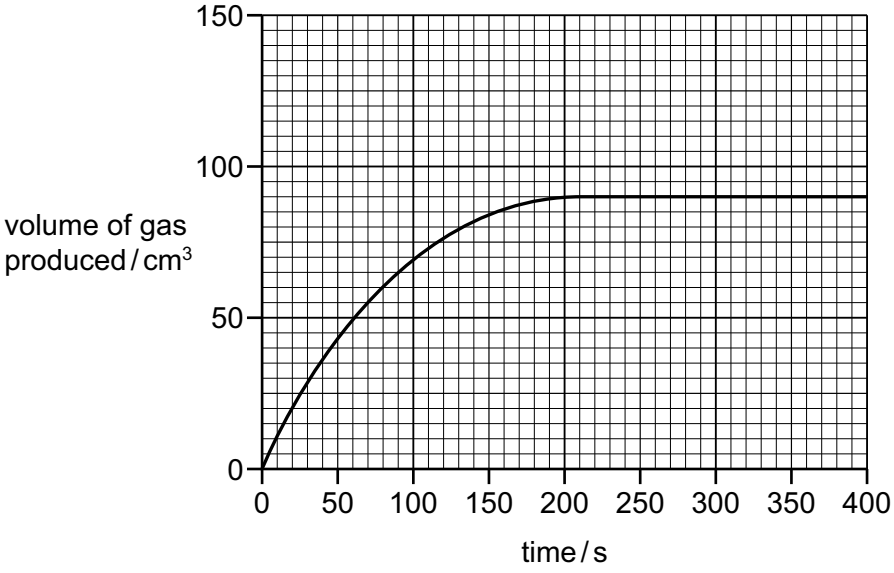


Fig. 5.2

(i) State how the shape of the graph shows that the rate of reaction decreases as the reaction progresses.

.....

..... [1]

(ii) Suggest why the rate of reaction decreases as the reaction progresses. **(extended only)**

.....

..... [1]

(iii) Deduce the time at which the reaction finishes.

..... s [1]

(b) The experiment is repeated using the same mass of smaller pieces of marble.

All other conditions are kept the same.

Draw a line **on the grid** in Fig. 5.2 to show the progress of the reaction using the smaller pieces of marble. [2]

(c) The original experiment is repeated at a higher temperature. All other conditions are kept the same. The resulting increase in rate of reaction can be explained in terms of activation energy and collisions between particles.

(i) Define the term activation energy. **(extended only)**

.....

..... [2]

(ii) Explain why the rate of a reaction increases when temperature increases, in terms of activation energy and collisions between particles. **(extended only)**

.....

.....

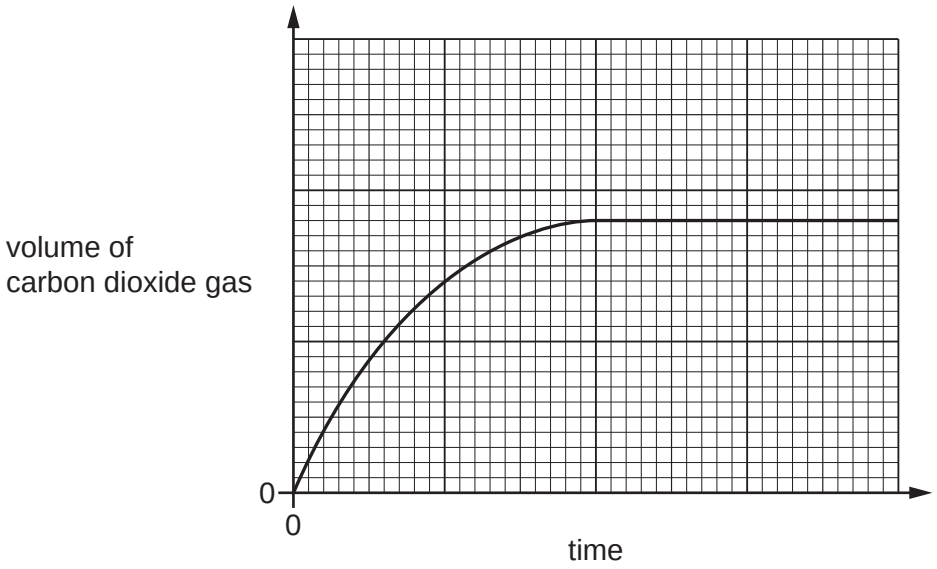
.....

.....

..... [3]

[Total: 10]

13 (d) The graph shows how the volume of carbon dioxide gas changes with time.



(i) Describe how the graph shows that the rate of this reaction decreases as time increases.

.....

..... [1]

(ii) Explain, in terms of particles, why the rate of this reaction decreases as time increases.

(extended only)

.....

..... [2]

(iii) The student repeats the experiment using powdered $MgCO_3$ instead of large pieces.

All other conditions stay the same.

On the grid, draw the line expected when powdered $MgCO_3$ is used instead of large pieces. [2]

14 Ammonia is made in an industrial process starting with nitrogen. The equation for the reaction is shown.

$$N_2 + 3H_2 \rightleftharpoons 2NH_3$$

(g) Explain, in terms of particles, what happens to the rate of reaction when the temperature is reduced.

(extended only)

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.....

.....

..... [3]