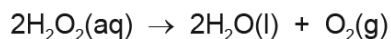


## 7.2 Rate (speed) of reaction

01. 0620\_w21\_qp\_43 Q: 6

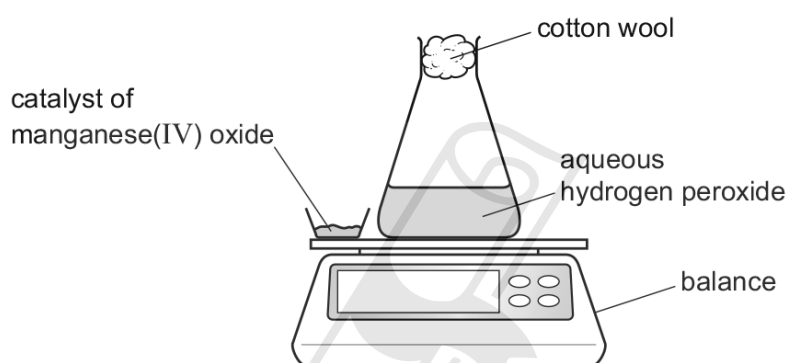
A student investigates the decomposition of hydrogen peroxide in the presence of a catalyst of manganese(IV) oxide.



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

.....  
..... [2]

(b) The diagram shows the equipment the student uses.



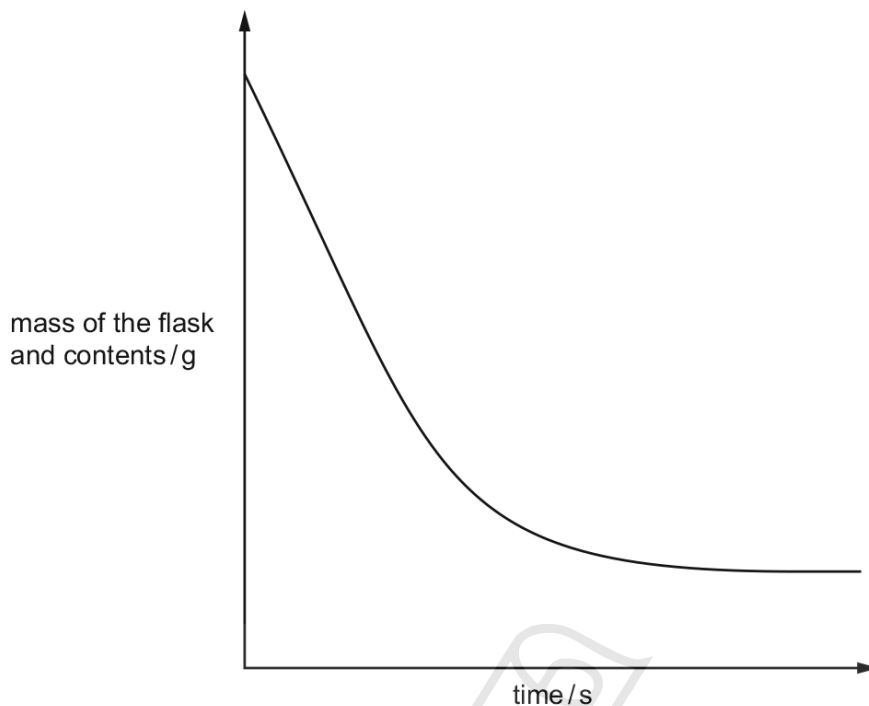
The student uses this method:

- the catalyst is added to the aqueous hydrogen peroxide
- the stop-clock is started
- the mass of the flask and contents is recorded at regular time intervals.

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7.2. RATE (SPEED) OF REACTION

A graph of the mass of the flask and contents against time is shown.



(i) Suggest why the mass of the flask and contents decreases as time increases.  
..... [1]

(ii) Describe what happens to the rate of the reaction as time increases.  
.....  
..... [2]

(c) The student repeats the experiment at a higher temperature. All other conditions stay the same. The rate of reaction increases.

(i) Explain, in terms of collisions between particles, why the rate of reaction increases at a higher temperature.  
.....  
.....  
.....  
..... [3]

(ii) Draw a line on the graph in (b) for the experiment at a higher temperature. [2]

[Total: 10]

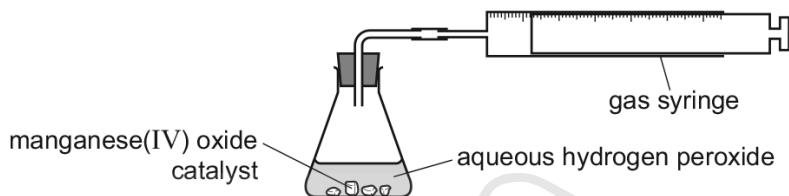
02. 0620\_s20\_qp\_42 Q: 4

Oxygen is produced by the decomposition of hydrogen peroxide. Manganese(IV) oxide is the catalyst for this reaction.

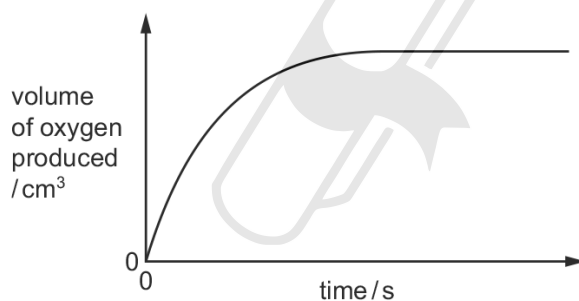
(a) What is meant by the term *catalyst*?

.....  
 .....  
 ..... [2]

(b) A student measures the volume of oxygen produced at regular time intervals using the apparatus shown. Large lumps of manganese(IV) oxide are used.



A graph of the results is shown.



What happens to the **rate** of this reaction as time increases?  
 In your answer, explain why the rate changes in this way.

.....  
 .....  
 .....  
 .....  
 ..... [4]

(c) The experiment is repeated using the same mass of manganese(IV) oxide. Powdered manganese(IV) oxide is used instead of large lumps. All other conditions stay the same.

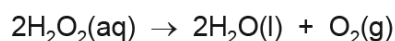
Sketch a graph on the axes in (b) to show how the volume of oxygen changes with time. [2]

7.2. RATE (SPEED) OF REACTION

(d) In terms of particles, explain what happens to the rate of this reaction when the temperature is increased.

.....  
.....  
.....  
.....  
..... [3]

(e) The equation for the decomposition of hydrogen peroxide is shown.



25.0 cm<sup>3</sup> of aqueous hydrogen peroxide forms 48.0 cm<sup>3</sup> of oxygen at room temperature and pressure (r.t.p.).

Calculate the concentration of aqueous hydrogen peroxide at the start of the experiment using the following steps.

- Calculate the number of moles of oxygen formed.

..... mol

- Deduce the number of moles of hydrogen peroxide that decomposed.

..... mol

- Calculate the concentration of hydrogen peroxide in mol/dm<sup>3</sup>.

..... mol/dm<sup>3</sup>  
[3]

(f) Oxygen can also be produced by the decomposition of potassium chlorate(V), KClO<sub>3</sub>.

The only products of this decomposition are potassium chloride and oxygen.

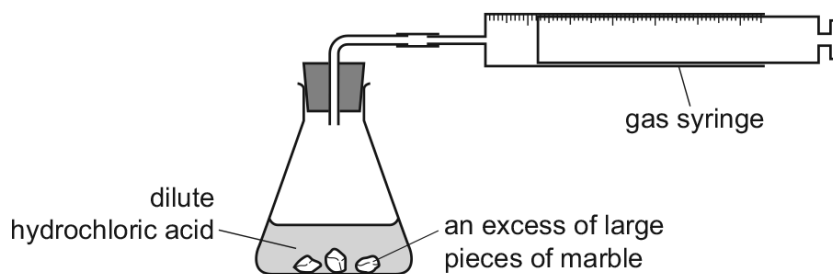
Write a chemical equation for this decomposition.

..... [2]

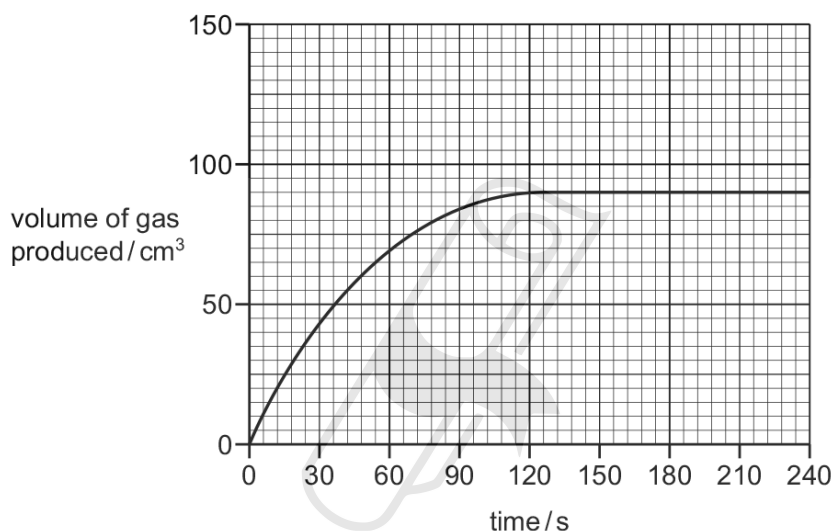
[Total: 16]

03. 0620\_w18\_qp\_42 Q: 4

A student investigated the progress of the reaction between dilute hydrochloric acid,  $\text{HCl}$ , and an excess of large pieces of marble,  $\text{CaCO}_3$ , using the apparatus shown.



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



(i) How does the shape of the graph show that the rate of reaction decreased as the reaction progressed?

.....  
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 ..... [1]

(ii) Why did the rate of reaction decrease as the reaction progressed?

..... [1]

(iii) After how many seconds did the reaction finish?

..... s [1]

(b) The experiment was repeated using the same mass of smaller pieces of marble. All other conditions were kept the same.

Draw a graph **on the grid** to show the progress of the reaction using the smaller pieces of marble. [2]

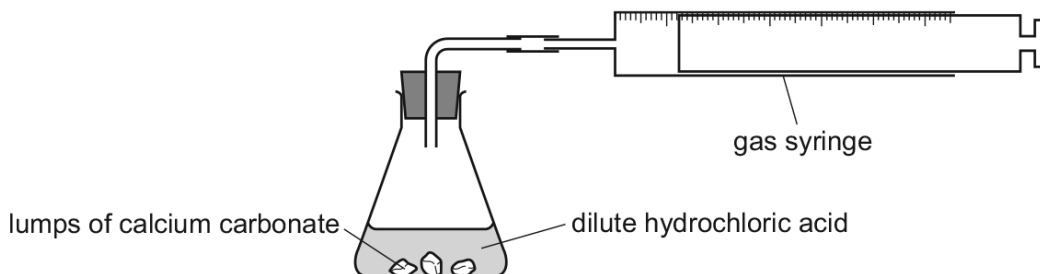


04. 0620\_w18\_qp\_43 Q: 5

A student investigates the rate of reaction between lumps of calcium carbonate and dilute hydrochloric acid using the apparatus shown.



The calcium carbonate was in excess.



- (a) Which measurements should the student make during the reaction to determine the rate of reaction?

.....  
 ..... [2]

- (b) What happens to the rate of reaction as the reaction proceeds? Explain your answer.

.....  
 .....  
 ..... [3]

- (c) The student repeated the experiment at a higher temperature. All other conditions were kept the same. The student found that the rate of reaction increased.

Explain, in terms of collisions, why the rate of reaction increased.

.....  
 .....  
 ..... [4]

- (d) Apart from using a higher temperature, suggest **two** other methods of increasing the rate of this reaction.

1 .....  
 2 ..... [2]

[Total: 11]

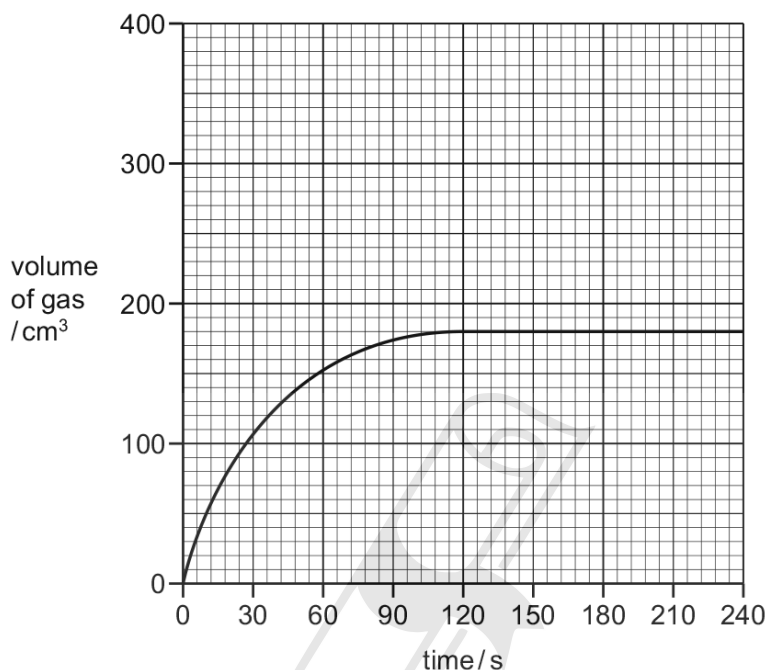
7.2. RATE (SPEED) OF REACTION

05. 0620\_s17\_qp\_41 Q: 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  $0.1 \text{ mol/dm}^3$  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.

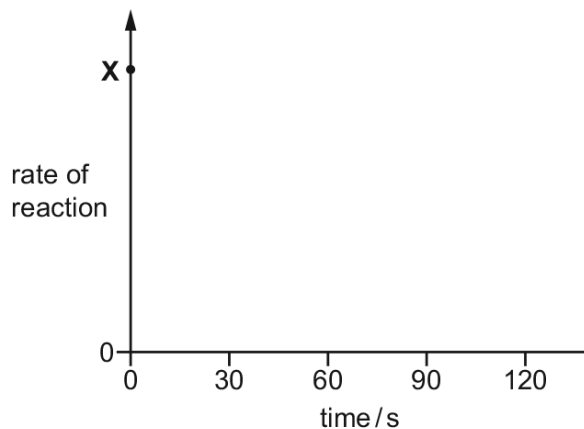
1 .....

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<sup>3</sup> at room temperature and pressure.

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

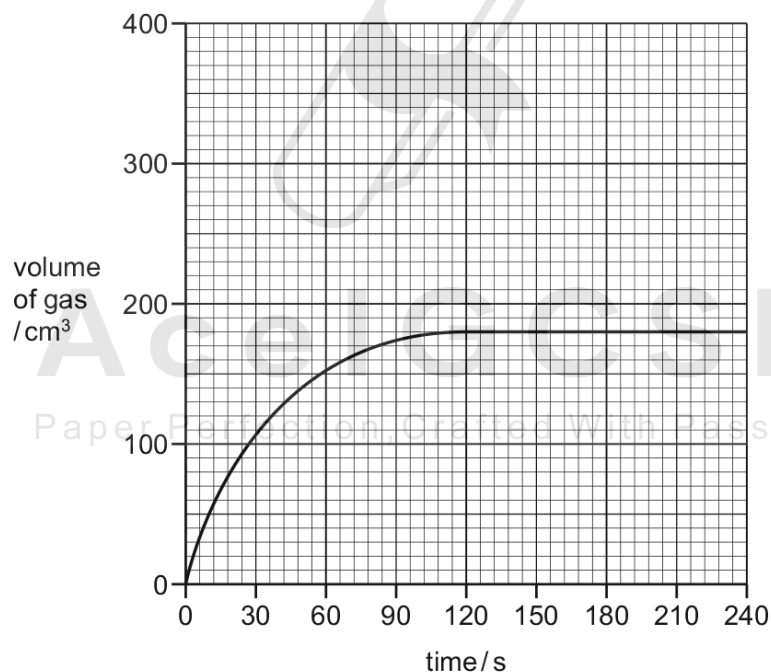


mass of barium carbonate = ..... g [3]

(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.



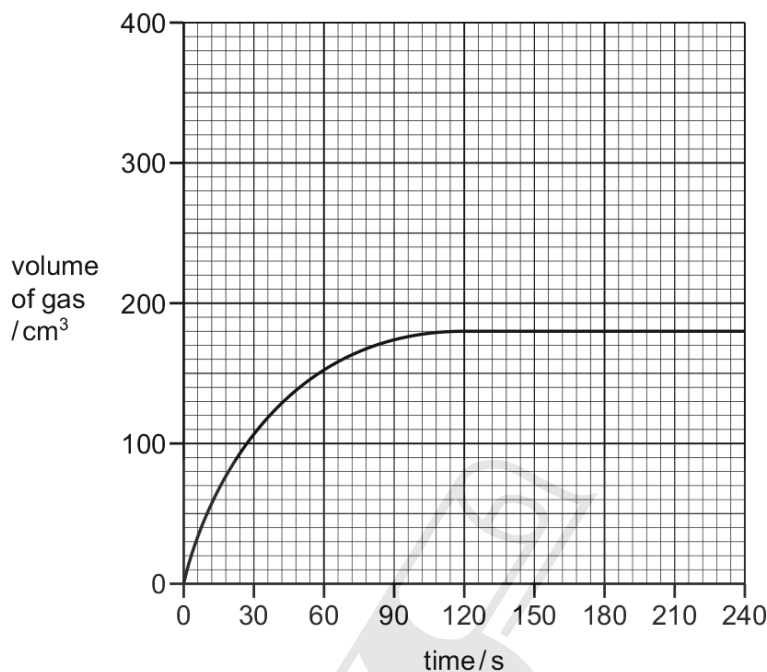
.....  
 .....  
 ..... [2]

7.2. RATE (SPEED) OF REACTION

(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  $0.1 \text{ mol/dm}^3$  to  $0.2 \text{ mol/dm}^3$ . 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.

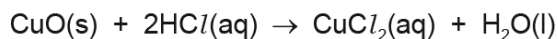
Deduce the volume of gas formed at room temperature and pressure, in  $\text{cm}^3$ , in this experiment.

volume of gas = .....  $\text{cm}^3$  [1]

[Total: 13]

06. 0620\_w17\_qp\_41 Q: 7

Copper(II) oxide reacts with dilute hydrochloric acid.



6.00 g of copper(II) oxide were added to 50.0 cm<sup>3</sup> of 1.00 mol/dm<sup>3</sup> 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]



7.2. RATE (SPEED) OF REACTION

(b) (i) Calculate the number of moles of copper(II) oxide added to the hydrochloric acid.

moles of copper(II) oxide = ..... mol [2]

(ii) Calculate the number of moles of hydrochloric acid used.

moles of hydrochloric acid = ..... mol [1]

(iii) Calculate the mass of copper(II) oxide that did **not** react.

mass of copper(II) oxide that did **not** react = ..... g [2]

(c) Crystals of hydrated copper(II) chloride were obtained from the solution at the end of the reaction.

The crystals had the following composition by mass: Cl, 41.52%; Cu, 37.43%; H, 2.34%; O, 18.71%.

Calculate the empirical formula of the crystals.



empirical formula = ..... [2]

[Total: 11]

07. 0620\_p16\_qp\_40 Q: 3

Kinetic theory explains the properties of matter in terms of the arrangement and movement of particles.

- (a) Nitrogen is a gas at room temperature. Nitrogen molecules,  $N_2$ , are spread far apart and move in a random manner at high speed.
- (i) Draw the electronic structure of a nitrogen molecule.  
Show only the outer electron shells.

[2]

- (ii) Compare the movement and arrangement of the molecules in solid nitrogen to those in nitrogen gas.

.....

.....

.....

..... [3]

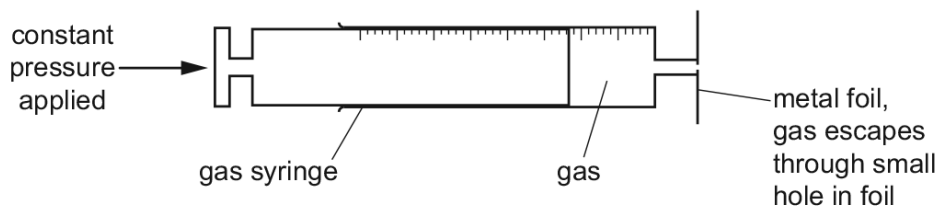
- (b) A sealed container contains nitrogen gas. The pressure of the gas is due to the molecules of the gas hitting the walls of the container.  
Use the kinetic theory to explain why the pressure inside the container increases when the temperature is increased.

.....

..... [2]

7.2. RATE (SPEED) OF REACTION

The following apparatus can be used to measure the rate of diffusion of a gas.



The following results were obtained.

gas	temperature /°C	rate of diffusion in cm <sup>3</sup> /min
nitrogen	25	1.00
chlorine	25	0.63
nitrogen	50	1.05

(c) (i) Explain why nitrogen gas diffuses faster than chlorine gas.

.....  
..... [2]

(ii) Explain why the nitrogen gas diffuses faster at the higher temperature.

..... [1]

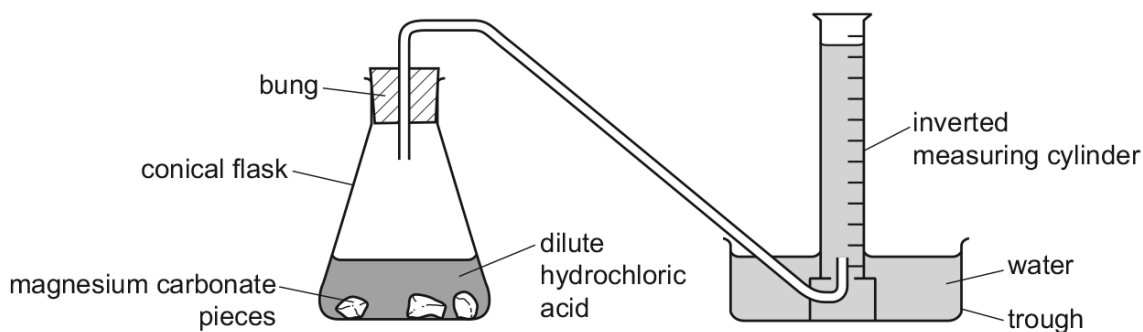
[Total: 10]

08. 0620\_w16\_qp\_41 Q: 8

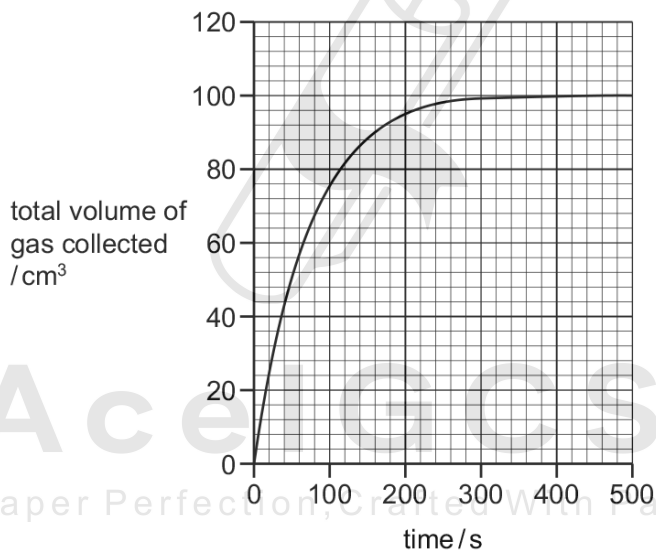
Magnesium carbonate reacts with dilute hydrochloric acid.



An excess of magnesium carbonate pieces was added to dilute hydrochloric acid. The apparatus in the diagram was used to measure the volume of gas produced. The total volume of gas collected was recorded every 20 seconds.



(a) The results obtained are shown on the graph.



(i) Describe how the rate of this reaction changed during the reaction. Explain why the rate changed in this way.

.....

.....

.....

.....

.....

..... [4]

7.2. RATE (SPEED) OF REACTION

- (ii) The experiment was repeated using the same mass of **powdered** magnesium carbonate with the same volume and concentration of dilute hydrochloric acid.

Explain how the initial rate of reaction and total volume of gas collected would compare to the first experiment.

initial rate of reaction .....

.....

.....

total volume of gas .....

.....

.....

[4]

- (b) A piece of magnesium ribbon was cleaned. The experiment was repeated using this clean magnesium ribbon instead of magnesium carbonate.



This reaction is exothermic.

The rate of the reaction gradually increased over the first 2 minutes.

Explain why the rate of the reaction increased.

.....

.....

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.....

..... [5]

[Total: 13]

09. 0620\_s13\_qp\_31 Q: 3

A small piece of marble,  $\text{CaCO}_3$ , was added to  $5.0\text{ cm}^3$  of hydrochloric acid, concentration  $1.0\text{ mol/dm}^3$ , at  $25\text{ }^\circ\text{C}$ . The time taken for the reaction to stop was measured. The experiment was repeated using  $5.0\text{ cm}^3$  of different solutions of acids. The acid was in excess in all of the experiments.

Typical results are given in the table.

experiment	temperature/ $^\circ\text{C}$	acid solution	time/min
1	25	hydrochloric acid $1.0\text{ mol/dm}^3$	3
2	25	hydrochloric acid $0.5\text{ mol/dm}^3$	7
3	25	ethanoic acid $1.0\text{ mol/dm}^3$	10
4	15	hydrochloric acid $1.0\text{ mol/dm}^3$	8

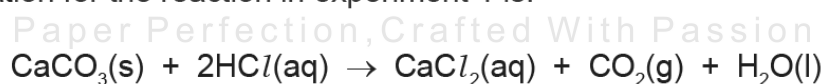
- (a) (i) Explain why it is important that the pieces of marble are the same size and the same shape.

.....  
 .....  
 ..... [2]

- (ii) How would you know when the reaction had stopped?

..... [1]

- (b) The equation for the reaction in experiment 1 is:



Complete the following ionic equation.



[1]

7.2. RATE (SPEED) OF REACTION

(c) (i) Explain why the reaction in experiment 1 is faster than the reaction in experiment 2.

.....  
..... [1]

(ii) The acids used for experiment 1 and experiment 3 have the same concentration. Explain why experiment 3 is slower than experiment 1.

.....  
..... [2]

(iii) Explain in terms of collisions between reacting particles why experiment 4 is slower than experiment 1.

.....  
..... [3]

[Total: 10]



10. 0620\_s13\_qp\_33 Q: 2

One of the factors which determine the reaction rate of solids is particle size.

- (a) A mixture of finely powdered aluminium and air may explode when ignited. An explosion is a very fast exothermic reaction. This causes a large and sudden increase in temperature.

Explain each of the following in terms of collisions between reacting particles.

- (i) Why is the reaction between finely powdered aluminium and air very fast?

.....  
 ..... [2]

- (ii) Explain why for most reactions the rate of reaction decreases with time.

.....  
 ..... [2]

- (iii) Suggest an explanation why the rate of reaction in an explosion could increase rather than decrease with time.

.....  
 .....  
 ..... [3]

- (b) (i) Give another example of a substance other than a metal which, when finely powdered, might explode when ignited in air.

..... [1]

- (ii) Describe a simple test-tube reaction which shows the effect of particle size on the rate at which a solid reacts with a solution.

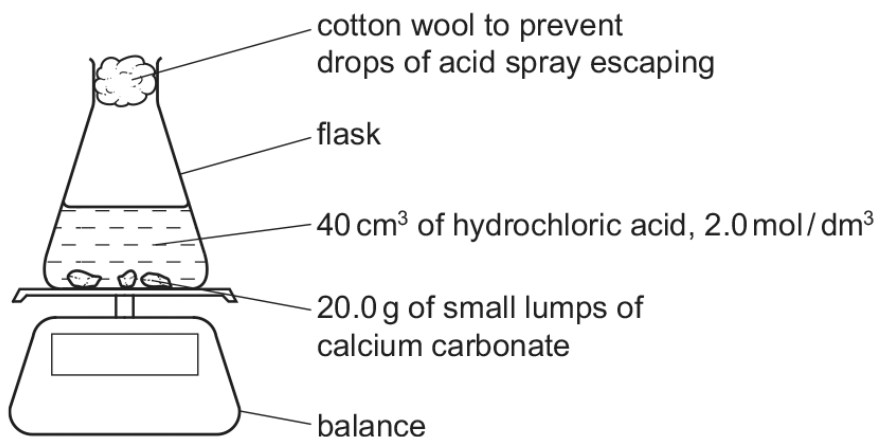
.....  
 .....  
 ..... [3]

[Total: 11]

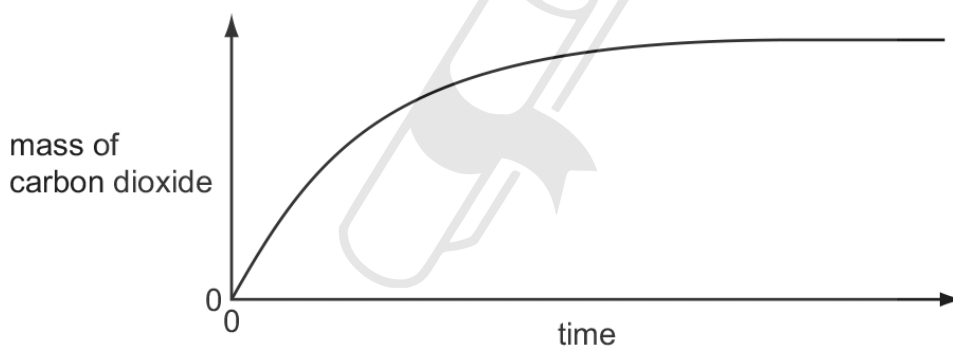
7.2. RATE (SPEED) OF REACTION

11. 0620\_w13\_qp\_31 Q: 4

20.0 g of small lumps of calcium carbonate and 40 cm<sup>3</sup> of hydrochloric acid, concentration 2.0 mol/dm<sup>3</sup>, were placed in a flask on a top pan balance. The mass of the flask and contents was recorded every minute.



The mass of carbon dioxide given off was plotted against time.



In all the experiments mentioned in this question, the calcium carbonate was in excess.

(a) (i) Explain how you could determine the mass of carbon dioxide given off in the first five minutes.

..... [1]

(ii) Label the graph **F** where the reaction rate is the fastest, **S** where it is slowing down and **0** where the rate is zero. [2]

(iii) Explain how the shape of the graph shows where the rate is fastest, where it is slowing down and where the rate is zero.

.....  
 .....  
 ..... [2]

- (b) Sketch on the same graph, the line which would have been obtained if 20.0 g of small lumps of calcium carbonate and 80 cm<sup>3</sup> of hydrochloric acid, concentration 1.0 mol / dm<sup>3</sup>, had been used. [2]



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7.2. RATE (SPEED) OF REACTION

(c) Explain in terms of collisions between reacting particles each of the following.

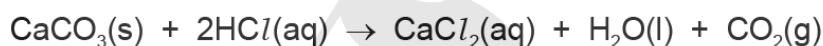
(i) The reaction rate would be slower if 20.0g of larger lumps of calcium carbonate and 40 cm<sup>3</sup> of hydrochloric acid, concentration 2.0 mol / dm<sup>3</sup>, were used.

.....  
.....  
..... [2]

(ii) The reaction rate would be faster if the experiment was carried out at a higher temperature.

.....  
.....  
..... [2]

(d) Calculate the maximum mass of carbon dioxide given off when 20.0g of small lumps of calcium carbonate react with 40 cm<sup>3</sup> of hydrochloric acid, concentration 2.0 mol / dm<sup>3</sup>.



number of moles of HCl used =



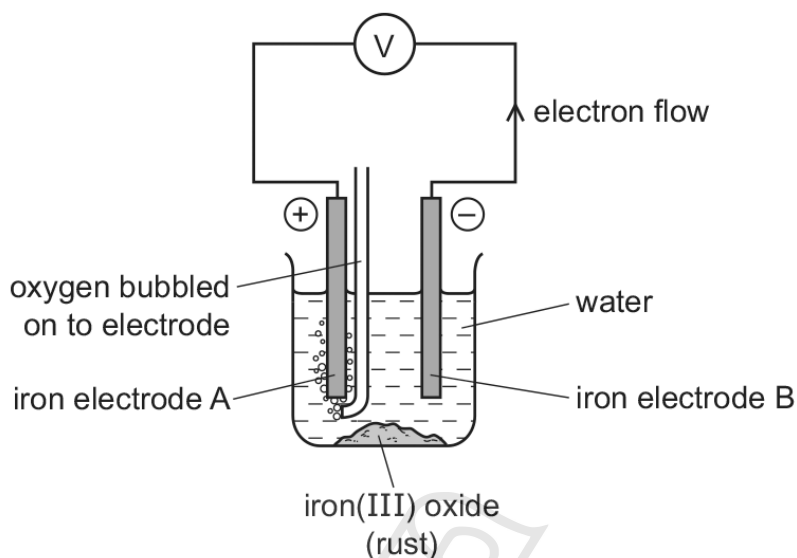
mass of carbon dioxide = ..... g [4]

[Total: 15]

12. 0620\_s12\_qp\_31 Q: 8

Iron and steel rust when exposed to water and oxygen. Rust is hydrated iron(III) oxide.

(a) The following cell can be used to investigate rusting.



(i) What is a cell?

.....  
 ..... [2]

(ii) Which electrode will be oxidised and become smaller? Explain your choice.

.....  
 ..... [3]

(iii) What measurements would you need make to find the rate of rusting of the electrode you have chosen in (ii)?

.....  
 ..... [2]

(iv) Suggest an explanation why the addition of salt to the water increases the rate of rusting.

..... [1]

7.2. RATE (SPEED) OF REACTION

(b) A sample of rust had the following composition:

51.85g of iron            22.22g of oxygen            16.67g of water.

Calculate the following and then write the formula for this sample of rust.

number of moles of iron atoms, Fe = ..... [1]

number of moles of oxygen atoms, O = ..... [1]

number of moles of water molecules, H<sub>2</sub>O = ..... [1]

simplest mole ratio Fe : O : H<sub>2</sub>O is ..... : ..... : .....

formula for this sample of rust is ..... [1]

[Total: 12]



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01. 0620\_w21\_ms\_43 Q: 6

Question	Answer	Marks
(a)	<b>M1</b> (a substance that) speeds up a reaction / increases the rate of a reaction (1) <b>M2</b> unchanged chemically at the end (1)	2
(b)(i)	oxygen gas escapes	1
(b)(ii)	<b>M1</b> rate decreases <b>OR</b> rate / reaction is fastest at the start (1) <b>M2</b> reaction stops or rate = zero (1)	2
(c)(i)	<b>M1</b> (particles) have more kinetic energy / particles move faster(1) <b>M2</b> more collisions per unit time (1) <b>M3</b> more particles have energy greater than or equal to activation energy <b>OR</b> more particles have sufficient energy to react <b>OR</b> A greater percentage or greater proportion or greater fraction of collisions have sufficient energy to react <b>OR</b> A greater percentage or greater proportion or greater fraction of collisions have energy greater than or equal to activation energy <b>OR</b> A greater percentage or greater proportion or greater fraction of collisions are successful (1)	3
(c)(ii)	<b>M1</b> steeper gradient from start (1) <b>M2</b> levels off at the same mass (1)	2

02. 0620\_s20\_ms\_42 Q: 4

(a)	substance that speeds up a reaction / increases rate (1) unchanged (chemically) at the end <b>OR</b> not used up <b>OR</b> lowers activation energy <b>OR</b> provides alternative pathway (1)	2
(b)	rate decreases (1) particles further apart / less particles per unit volume (1) fewer collisions per unit time / lower collision frequency (1) reaction stops because all hydrogen peroxide is used up	4
(c)	steeper gradient (1) reaches same volume of oxygen (1)	2
(d)	particles gain kinetic energy / particles move faster (1) greater number of collisions with activation energy (or more) / greater number of particles with activation energy (or more) / greater number of particles with energy required for reaction (1) more collisions are successful / more collisions are fruitful / more collisions lead to reaction (1)	3
(e)	<b>M1</b> moles of oxygen = $\frac{48.0}{24000}$ or moles of oxygen = 0.002 (1) <b>M2</b> moles of hydrogen peroxide = <b>M1</b> × 2 or moles of hydrogen peroxide = 0.004 (1) <b>M3</b> concentration = <b>M2</b> × 40 = 0.16 mol / dm <sup>3</sup> (1) allow ECF	3
(f)	$2\text{KClO}_3 \rightarrow 2\text{KCl} + 3\text{O}_2$ <b>ALL</b> formulae correct (1) balancing (1)	2

03. 0620\_w18\_ms\_42 Q: 4

(a)(i)	Gradient gets less	1
(a)(ii)	Concentration of HCl is decreasing	1
(a)(iii)	120 seconds	1
(b)	M1 New line steeper than printed line and starts at origin M2 New line reaches same final volume as printed line	2
(c)	M1 Time taken is less M2 (particles) have more energy M3 (particles) move faster M4 More collisions (of particles) occur per second / per unit time M5 More (of the) particles / collisions have energy greater than activation energy or More (of the) particles / collisions have sufficient energy to react or A greater percentage / proportion / fraction of collisions (of particles) are successful	5

04. 0620\_w18\_ms\_43 Q: 5

(a)	M1 volume of gas M2 time	2
(b)	M1 rate decreases / reaction gets slower M2 concentration of acid decreases M3 fewer collisions per unit time	3

(c)	<p><b>M1</b> particles have more kinetic energy</p> <p><b>M2</b> particles move faster</p> <p><b>M3</b> more collisions per unit time</p> <p><b>M4</b> more of the particles have energy greater than or equal to activation energy / more of the collisions have energy greater than or equal to activation energy</p> <p><b>OR</b></p> <p>more of the particles have sufficient energy to react / more of the collisions have sufficient energy to react</p> <p><b>OR</b></p> <p>A greater percentage or greater proportion or greater fraction of collisions are successful</p>	4
(d)	<p><b>ANY TWO FROM:</b></p> <p><input type="checkbox"/> increase concentration of hydrochloric acid</p> <p><input type="checkbox"/> decrease particle size of calcium carbonate / increase surface area of calcium carbonate</p> <p><input type="checkbox"/> (add)catalyst</p>	2

05. 0620\_s17\_ms\_41 Q: 5

(a)	(stop-) watch <b>AND</b> syringe	1
(b)	graph starts at X and is a curve with a decreasing gradient	1
	graph hits zero rate at 114 $\square$ 6 seconds	1
(c)	<b>M1</b> moles of carbon dioxide = $180 / 24\ 000 = 0.0075$	1
	<b>M2</b> molar mass of barium carbonate = 197	1
	<b>M3</b> mass of barium carbonate = $M1 \square M2 = 1.48$ (g)	1
(d)	curve starts from (0,0) and has a lower gradient than the original curve	1
	because lumps have a lower surface area	1
(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 / $\text{dm}^3 / \text{cm}^3$	1
	because there are more collisions per second / unit time <b>OR</b> a greater collision rate	1
(f)	360 ( $\text{cm}^3$ )	1

06. 0620\_w17\_ms\_41 Q: 7

(a)(i)	more particles (of acid) in a given volume / $\text{dm}^3 / \text{cm}^3$	1
	more collisions per second / unit time <b>OR</b> greater collision rate	1
(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
(b)(i)	0.075 If full credit is not awarded, allow 1 mark for $M_r$ of CuO = 80	2
(b)(ii)	0.05	1
(b)(iii)	4 (g) <b>M1</b> moles copper(II) oxide that reacted = $(0.05 / 2) = 0.025$ mol <b>M2</b> mass copper(II) oxide = $((0.075 - 0.025) \square 80) = 4$ g	2
(c)	$\text{C}_2\text{CuH}_4\text{O}_2$ <b>M1</b> 41.52 / 35.5; 37.43 / 64; 2.34 / 1; 18.71 / 16 <b>OR</b> 1.17 : 0.58 : 2.34 : 1.17 <b>M2</b> appropriate scaling to give whole number ratios	2

07. 0620\_p16\_ms\_40 Q: 3

- (a) (i) 6e between two nitrogen atoms; note: can be any combination of dots or crosses [1]  
 1 lone pair on each nitrogen atom; [1]
- (ii)
- |           |                          |                                  |     |
|-----------|--------------------------|----------------------------------|-----|
|           | solid                    | gas                              |     |
| pattern:  | regular / lattice        | random / irregular / no pattern; | [1] |
| distance: | close                    | far apart / spread out;          | [1] |
| movement: | vibrate / fixed position | moving;                          | [1] |
- note: comparison must be made
- (b) particles have more energy / move faster; [1]  
 collide harder / collide more frequently / more collisions / collide with more force; [1]  
 allow: molecules instead of particles
- (c) (i) nitrogen has smaller  $M_r$ ; [1]  
 nitrogen (molecules) move faster (than chlorine molecules) / ora; [1]  
 note: comparison must be made
- (ii) (at higher temperature) molecules move faster / have more energy [1]

08. 0620\_w16\_ms\_41 Q: 8

(a)(i)	any 4 from: slowed down acid became less concentrated <b>OR</b> fewer particles per unit volume fewer collisions per second <b>OR</b> lower collision rate (then the reaction) stopped all the hydrochloric acid reacted	4
(a)(ii)	any 4 from: faster (reaction) (powder has) larger surface area more collisions per second <b>OR</b> higher collision rate same volume of gas amount / moles hydrochloric acid is not changed	4
(b)	any 5 from: temperature increased particles have more energy (particles) move faster more collisions per second <b>OR</b> higher collision rate more particles have sufficient energy to react / activation energy more of the collisions are successful	5

09. 0620\_s13\_ms\_31 Q: 3

(a) (i) pieces have (same) surface area [1]  
 same amount / mass / quantity / volume / number of moles of carbonate [1]

(ii) no more bubbles / carbon dioxide **or** piece disappears / dissolves [1]

(b) experiment 1  $\text{Ca}^{2+} + \text{CO}_2 + \text{H}_2\text{O}$  [1]

(c) (i) more concentrated **or** higher concentration (of acid) (in experiment 1) [1]  
 accept: arguments based on collision theory

(ii) ethanoic acid is a weak acid **or** hydrochloric acid is a strong acid [1]  
 accept: stronger or weaker

ethanoic acid less ionised / dissociated / lower / smaller concentration of hydrogen ions [1]  
 accept: less hydrogen ions and vice versa argument but not dissociation of ions

(iii) lower temperature (particles) have less energy [1]  
 moving more slowly [1]  
 fewer collisions / lower collision rate [1]  
**or**  
 lower temperature (particles) have less energy [1]  
 fewer particles collide [1]  
 with the necessary energy to react [1]  
 note: less energy fewer successful collisions gains all 3 marks

**[Total: 10]**

10. 0620\_s13\_ms\_33 Q: 2

(a) (i) large / high surface area [1]

high collision rate / collide more / many collisions [1]  
(between oxygen molecules and aluminium atoms)  
**NOT** faster collisions

(ii) concentration [1]  
of reactants decreases [1]

allow one mark **ONLY** for:  
for reactants used up **or** amount of reactant decreases

(iii) any three of four from one strand:

<b>M1</b>	increase in temperature	
<b>M2</b>	molecules move faster <b>or</b>	particles have more energy
<b>M3</b>	higher collision rate	
<b>M4</b>	more successful collisions <b>or</b>	more particles have enough energy to react/ $E_a$

[3]

(b) (i) flour **or** wood dust **or** coal dust or carbon or sugar [1]

(ii) any three from:  
powder and larger pieces / different sized particles use  
suitable named solid, e.g. magnesium  
suitable named solution, e.g. named acid **or** copper sulfate(aq)  
result – powder reacts faster than larger pieces [3]  
**NOT** Cu (with acid); K / Na with anything

11. 0620\_w13\_ms\_31 Q: 4

(a) (i) (mass at  $t=0$ ) – (mass at  $t=5$ ) [1]  
**NOTE:** must have mass at  $t=5$  not final mass

(ii) fastest at origin  
slowing down between origin and flat section gradient = 0  
where gradient = 0  
**three** of above in approximately the correct positions [2]

(iii) 3 correct comments about gradient = [2]  
2 correct comments about gradient = [1]  
1 correct comment about gradient = [0] [2]

(b) start at origin and smaller gradient [1]  
same final mass just approximate rather than exact [1]

- (c) (i) smaller surface area [1]  
lower collision rate [1]
- (ii) molecules have more energy [1]  
collide more frequently / more molecules have enough energy to react [1]
- (d) number of moles of HCl in 40 cm<sup>3</sup> of hydrochloric acid, [1]  
concentration 2.0 mol / dm<sup>3</sup> = 0.04 × 2.0 = 0.08 [1]  
maximum number of moles of CO<sub>2</sub> formed = 0.04 [1]  
mass of one mole of CO<sub>2</sub> = 44 g [1]  
maximum mass of CO<sub>2</sub> lost = 0.04 × 44 = 1.76 g [1]

[Total: 15]

12. 0620\_s12\_ms\_31 Q: 8

- (a) (i) device which changes chemical energy; [1]  
into electrical energy; [1]  
**OR**  
produces a voltage / potential difference / electricity; [1]  
due to difference in reactivity of two metals; [1]  
**OR**  
produces a voltage / potential difference / electricity; [1]  
by redox reactions; [1]
- (ii) negative / electrode B / right electrode; [1]  
**accept:** anode because it is the electrode which supplies electrons to  
external circuit  
loses ions / iron ions / Fe<sup>2+</sup> or Fe<sup>3+</sup>; [1]  
electrons move from this electrode; [1]
- (iii) change of mass of electrode / mass of rust formed; [1]  
time / mention of stop watch / regular intervals; [1]
- (iv) to make it a better conductor; [1]
- (b) moles of Fe = 51.85/56 = 0.926 (0.93); [1]  
moles of O = 22.22/16 = 1.389 (1.39); [1]  
moles of H<sub>2</sub>O = 16.67/18 = 0.926 (0.93); [1]
- if given as 0.9 1.4 0.9  
**three** of the above correct = [2]  
**two** of the above correct = [1]
- simplest whole number mole ratio Fe : O : H<sub>2</sub>O is 2 : 3 : 2 / Fe<sub>2</sub>O<sub>3</sub>.2H<sub>2</sub>O; [1]  
**allow:** ecf for a formula based on an incorrect whole number ratio

[Total: 12]

(a) (i) A C D B [1]

(ii) speed (or rate) increases as concentration increases / time decreases as concentration increases; [1]

rate or speed or time depends on (concentration) of  $H^+$  or hydrogen ions; [1]

B is slow because propanoic acid is weak or doesn't dissociate or weakly ionises;

**or**

B is slow because  $HCl$  **and**  $H_2SO_4$  are stronger or ionise or dissociate more than propanoic; [1]

D slower than C because C is more concentrated than D / ORA; [1]

A is fast because  $H^+$  concentration high (**note:** this would also score second mark if not already awarded) /  $H_2SO_4$  is diprotic or dibasic or  $2H^+$ ; [1]

time is inversely proportional to rate / owtte / ORA; [1]

max [5]

(b) change 1:

increase temperature / heat (the mixture); [1]

particles/molecules/ions have more energy or move faster; [1]

more (successful) collisions / more particles with  $E_a$ ; [1]

change 2:

increase surface area / decrease particle size / use powdered (magnesium) / use smaller pieces / crush the magnesium; [1]

more collisions / more particles exposed to reaction; [1]

**or**

catalyst; [1]

more (successful) collisions; [1]

lowers  $E_a$ ; [1]

max [5]