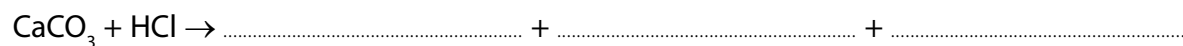


- 7 A student investigated the rate of reaction between dilute hydrochloric acid and marble chips (calcium carbonate).

Calcium chloride, carbon dioxide and water are formed.

- (a) Complete and balance the equation for the reaction.

(2)



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(b) The student investigated the rate by using different sizes of marble chips. In their investigation, the same mass of marble chips was used in each experiment.

The volume of gas given off was measured.

The graph in Figure 8 shows the results.

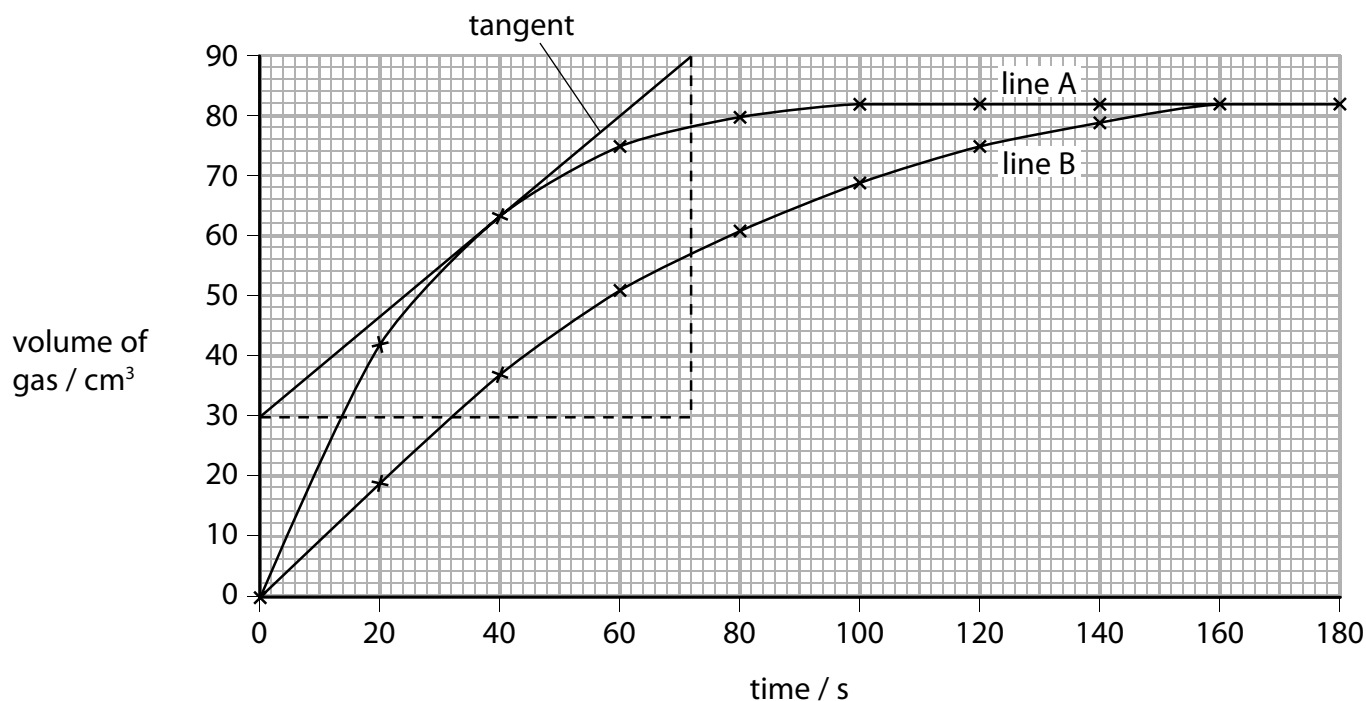


Figure 8

(i) State how the graph shows that line B gives the results for the larger marble chips.

(1)

(ii) A tangent has been drawn on line A.

Calculate the rate of reaction at this point.

(2)

rate of reaction = ..... cm<sup>3</sup> s<sup>-1</sup>

(c) During any reaction, reactants are used up and the rate of reaction decreases.

Explain, in terms of particles, why the rate of reaction decreases.

(2)

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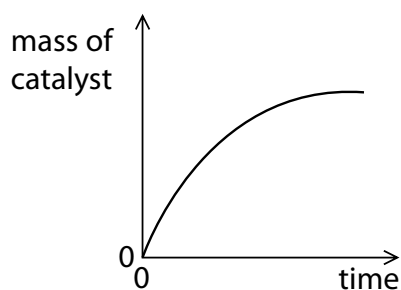
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(d) The decomposition of hydrogen peroxide is catalysed by adding a small amount of manganese(IV) oxide.

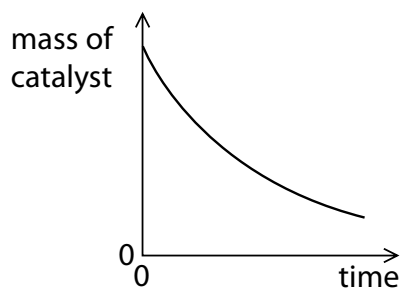
Which of these graphs shows the mass of the catalyst as the reaction takes place?

(1)

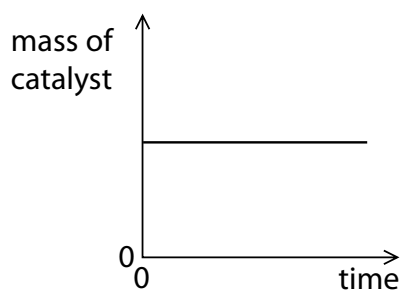
A



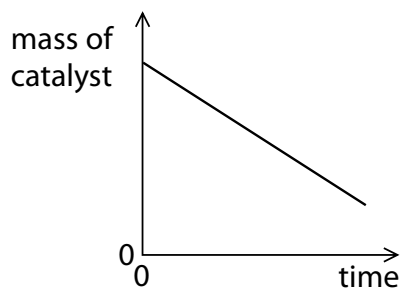
B



C



D



(e) Two gases, **X** and **Y**, react to give a gaseous product **Z**.

The reaction is carried out under two different sets of conditions in experiments 1 and 2 as shown in Figure 9.

condition	experiment 1	experiment 2
temperature/°C	30	20
pressure/atm	1	2

**Figure 9**

Explain why it is not possible to predict what the rate of Experiment 2 will be compared with Experiment 1.

(3)

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**(Total for Question 7 = 11 marks)**

10 (a) Each of these substances forms ions in solution.

One mole of the following substances is dissolved in 1 dm<sup>3</sup> of water.

Which solution contains the greatest number of ions?

(1)

- A ammonium sulfate, (NH<sub>4</sub>)<sub>2</sub>SO<sub>4</sub>
- B iron(III) chloride, FeCl<sub>3</sub>
- C magnesium nitrate, Mg(NO<sub>3</sub>)<sub>2</sub>
- D potassium bromide, KBr

(b) When sodium hydroxide solution is neutralised with an acid there is a temperature change.

A student is given dilute hydrochloric acid and dilute ethanoic acid of the same concentration in mol dm<sup>-3</sup>.

Devise a plan to compare the temperature changes produced when sodium hydroxide solution is neutralised with each of these two acids.

(4)

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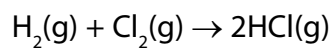
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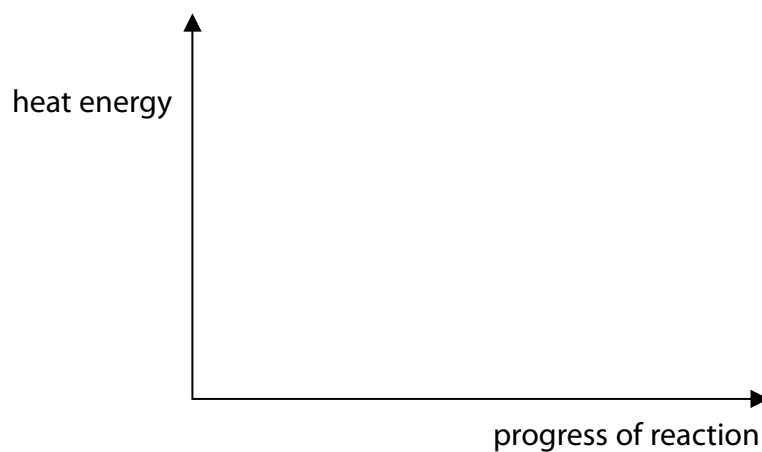
(c) Hydrogen reacts with chlorine to form hydrogen chloride.



The reaction is exothermic.

Draw and label the reaction profile diagram for this reaction, identifying the activation energy.

(3)

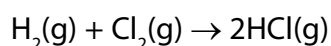


(d) The energies of some bonds are shown in Figure 13.

bond	energy of bond / kJ mol <sup>-1</sup>
H—H	436
Cl—Cl	243
H—Cl	432

**Figure 13**

Hydrogen reacts with chlorine to form hydrogen chloride.



Calculate the energy change, in kJ mol<sup>-1</sup>, for the reaction of 1 mol of hydrogen gas, H<sub>2</sub>, with 1 mol of chlorine gas, Cl<sub>2</sub>, to form 2 mol of hydrogen chloride gas, HCl.

(4)

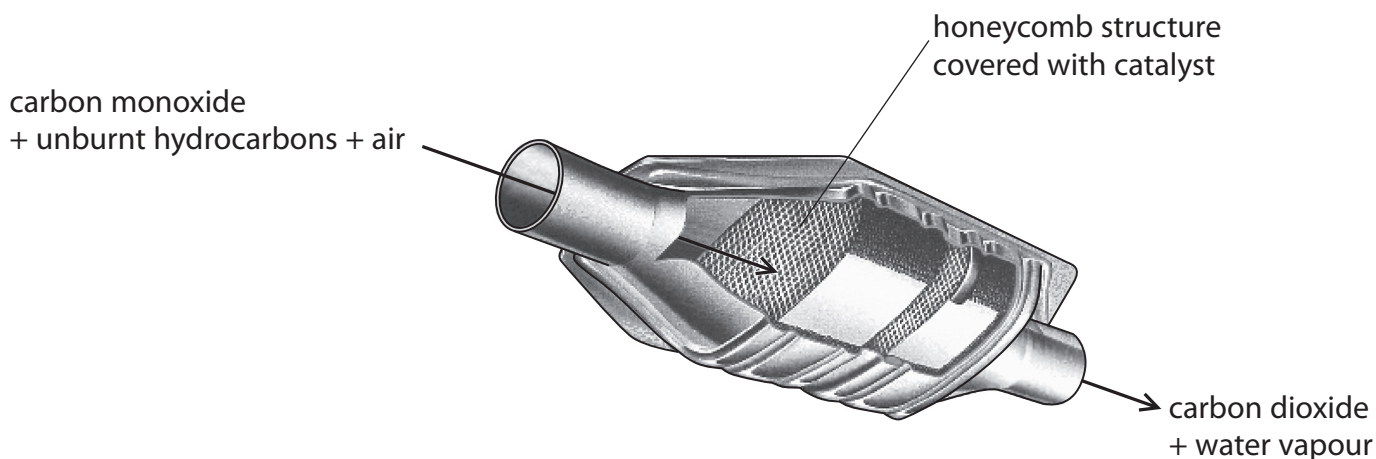
energy change = ..... kJ mol<sup>-1</sup>

**(Total for Question 10 = 12 marks)**

**TOTAL FOR PAPER = 100 MARKS**

### Rates of reaction

- 3 The diagram shows a catalytic converter used in car exhaust systems. Gases from the car engine pass into the catalytic converter. In the catalytic converter, carbon monoxide and unburnt hydrocarbons are changed into carbon dioxide and water vapour.



- (a) What type of reaction occurs in the catalytic converter?

Put a cross (☒) in the box next to your answer.

(1)

- A cracking
- B displacement
- C oxidation
- D precipitation

- (b) It is important that the reactions in the catalytic converter happen quickly.

- (i) Explain why the catalyst is spread onto the honeycomb structure rather than used as large pieces.

(2)

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(ii) Hot gases from the engine pass over the catalyst.

Explain why the catalyst is more effective when the engine has been running for a short time rather than when the engine is first started.

(2)

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(c) Carbon monoxide reacts with oxygen,  $O_2$ , to form carbon dioxide in the catalytic converter.

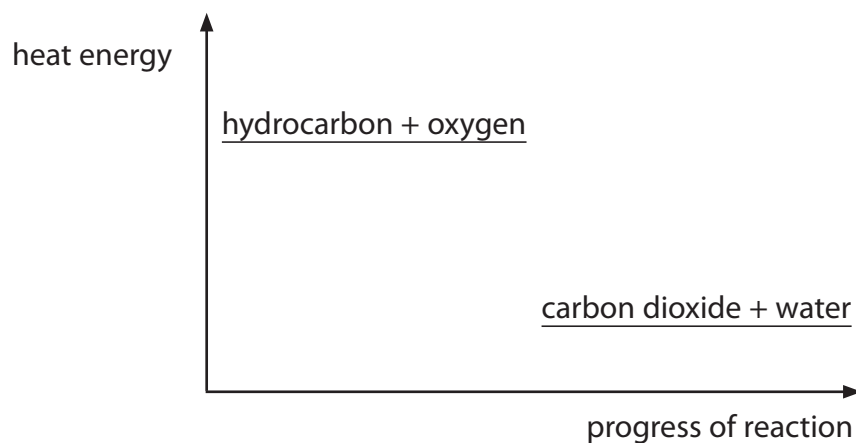
Write the balanced equation for this reaction.

(3)

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(d) In the catalytic converter, a hydrocarbon is converted to carbon dioxide and water.

The diagram shows the heat energies of the reactants and products in this reaction.



Explain what the diagram shows about the type of reaction occurring.

(2)

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**(Total for Question 3 = 10 marks)**



### Energy changes

- 5 (a) An experiment is carried out to measure the temperature change when solid ammonium chloride is dissolved in water.

initial temperature of water = 19 °C  
final temperature of solution = 15 °C

Explain what the temperature readings show about the type of heat change occurring when ammonium chloride dissolves in water.

(2)

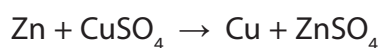
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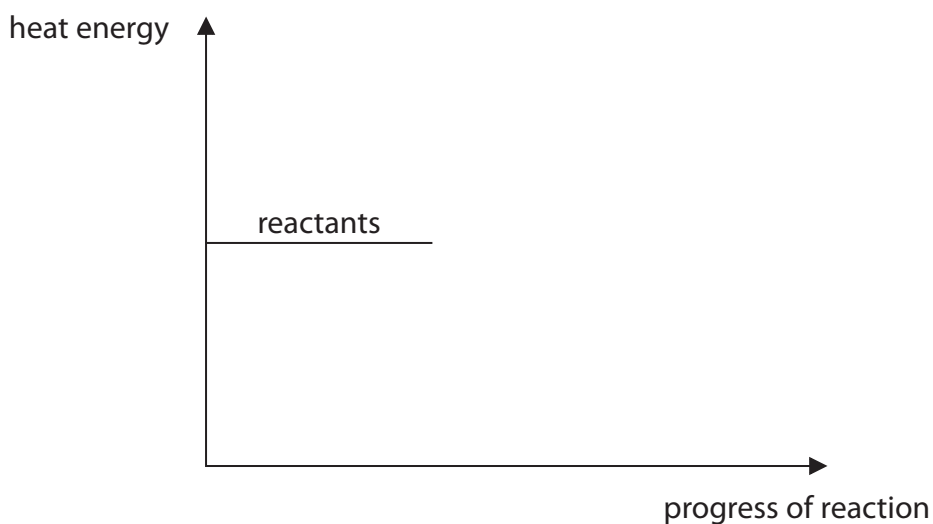
- (b) When zinc reacts with copper sulfate solution, copper and zinc sulfate solution are formed.



This reaction is exothermic.

Use this information to complete the diagram.

(2)



(c) Reactions are accompanied by heat changes.

The heat changes are the results of bonds being broken and bonds being formed.

Which row of the table shows the heat energy changes that occur when bonds are broken and when bonds are formed?

Put a cross (☒) in the box next to your answer.

(1)

	<b>bonds broken</b>	<b>bonds formed</b>
<input checked="" type="checkbox"/> <b>A</b>	heat energy is released	heat energy is released
<input checked="" type="checkbox"/> <b>B</b>	heat energy is required	heat energy is required
<input checked="" type="checkbox"/> <b>C</b>	heat energy is released	heat energy is required
<input checked="" type="checkbox"/> <b>D</b>	heat energy is required	heat energy is released



**\*(d)** Reactions can occur when particles collide.  
Rates of reactions can be altered by changing conditions.

Explain how the rate of reaction between a solid and a liquid is altered by changing the size of the pieces of solid and by changing the temperature of the liquid.

**(6)**

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**(Total for Question 5 = 11 marks)**



## Chemical reactions

3 (a) Catalytic converters in the exhaust systems of cars contain catalysts.

(i) Explain what is meant by the term **catalyst**.

(2)

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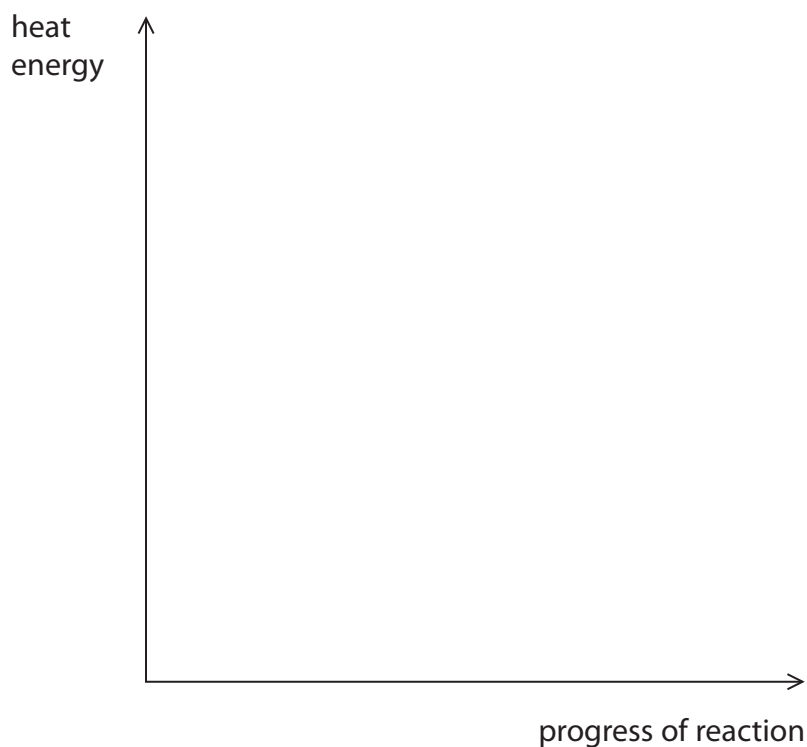
(ii) This reaction takes place in a catalytic converter



This reaction is exothermic.

On the axes below, draw labelled lines to show the relative energies of the reactants and products in this reaction.

(2)



(iii) Another reaction in a catalytic converter is the reaction of hydrocarbons with excess oxygen to form carbon dioxide and water.

Write the balanced equation for the reaction of the hydrocarbon heptane,  $C_7H_{16}$ , with excess oxygen.

(3)

(b) When reactions take place in a solution, the rate of reaction is affected by the concentration in the solution.

Explain, in terms of particles and collisions, why the rate of a reaction increases when the concentration of one of the reactants is increased.

(2)

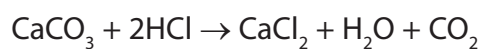
(Total for Question 3 = 9 marks)



### Rates of reactions and energy changes

- 2 (a) Marble chips react with hydrochloric acid to produce carbon dioxide.

The equation for the reaction is



Which one of these changes would **decrease** the rate of this reaction?

Put a cross (☒) in the box next to your answer.

(1)

- A use hydrochloric acid which is more dilute
- B use smaller sized marble chips
- C use marble chips which have a larger surface area
- D use a larger volume of the hydrochloric acid

- (b) Explain why increasing the temperature of a reaction increases the rate of the reaction.

(2)

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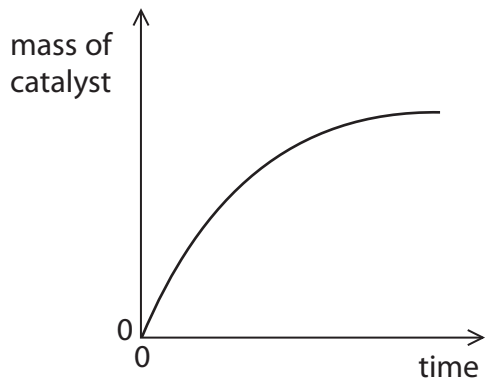
(c) (i) The rate of decomposition of hydrogen peroxide can be increased by adding a catalyst.

Which of these graphs shows the mass of the catalyst during the reaction?

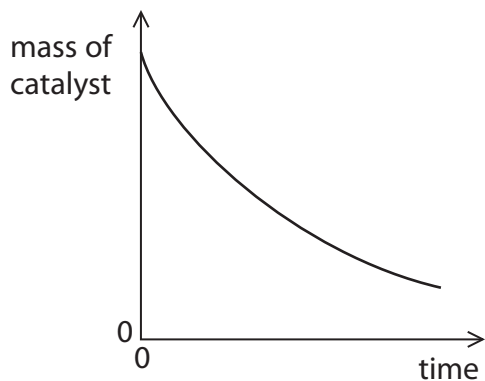
Put a cross (☒) in the box next to your answer.

(1)

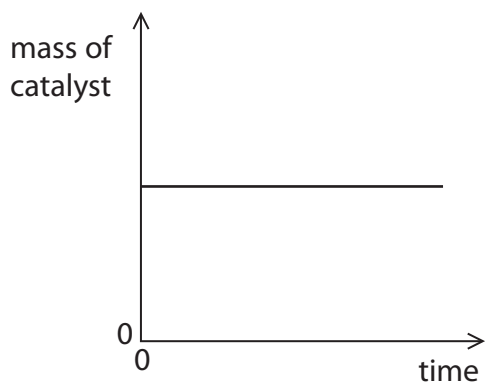
**A**



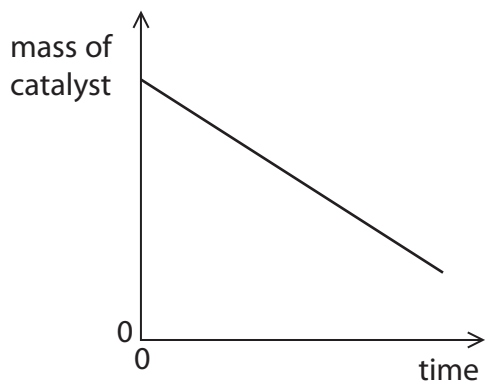
**B**



**C**



**D**





(ii) The decomposition of hydrogen peroxide,  $\text{H}_2\text{O}_2$ , produces oxygen and water.

Give the balanced equation for this reaction.

(2)

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(d) Explain, in terms of the energy involved in the breaking of bonds and in the making of bonds, why some reactions are exothermic.

(2)

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**(Total for Question 2 = 8 marks)**

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**Answer ALL questions**

Some questions must be answered with a cross . If you change your mind about an answer, put a line through the box  and then mark your new answer with a cross .

**Energy changes**

- 1 (a) The neutralisation reaction between ethanoic acid and sodium carbonate is an endothermic reaction.

Describe what is meant by the term **endothermic reaction**.

(2)

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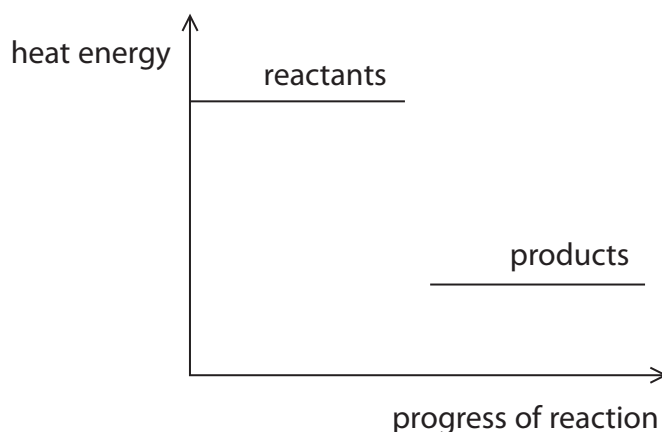
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- (b) The reaction between magnesium ribbon and dilute hydrochloric acid produces magnesium chloride and hydrogen.

The diagram shows the energies of the reactants and the products.



Explain what the diagram shows about the type of reaction occurring between the magnesium ribbon and dilute hydrochloric acid.

(2)

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(c) The rate of the reaction between magnesium ribbon and hydrochloric acid can be increased by increasing the concentration of the acid.

(i) State **two other** ways of increasing the rate of this reaction.

(2)

1 .....

2 .....

(ii) Explain, in terms of particles, why increasing the concentration of the acid increases the rate of this reaction.

(2)

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**(Total for Question 1 = 8 marks)**

