1 (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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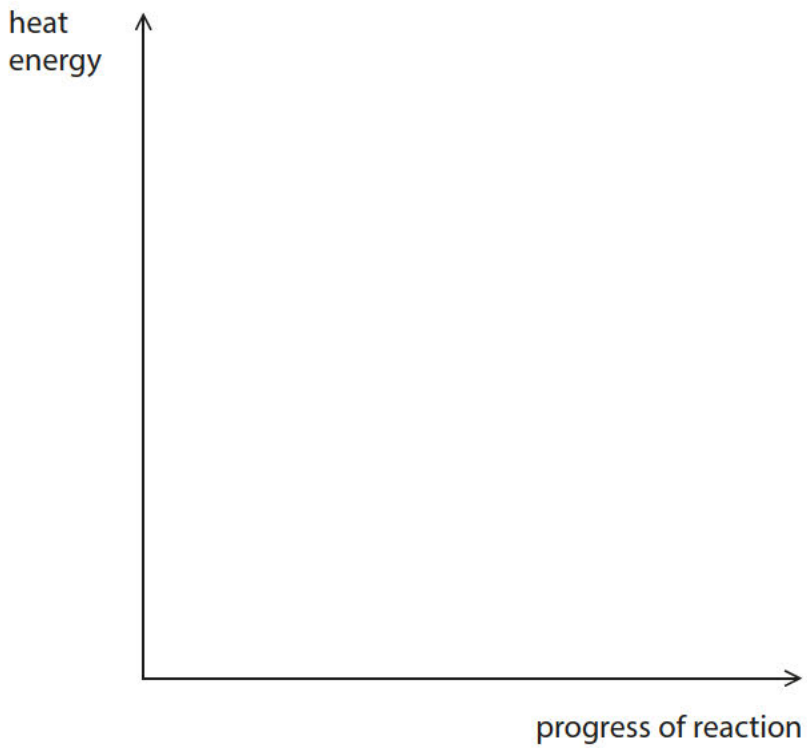
(ii) This reaction takes place in a catalytic converter

carbon monoxide + oxygen → carbon dioxide

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 1 = 9 marks)

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

The equation for the reaction is

$$CaCO_3 + 2HCl \rightarrow CaCl_2 + H_2O + CO_2$$

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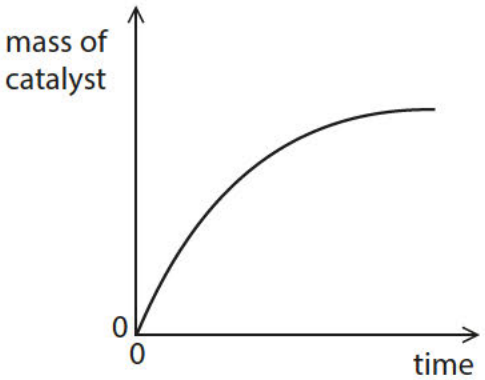
(c) (i) The rate of decomposition of hydrogen peroxide can be increased by adding a catalyst.

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

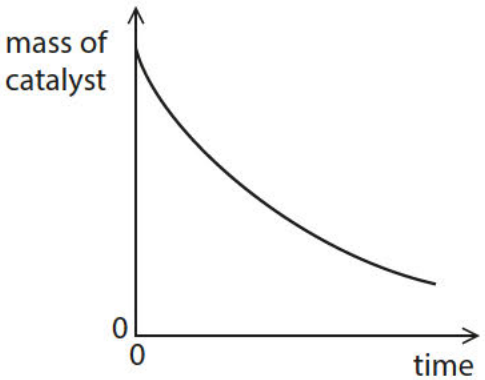
Put a cross (☒) in the box next to your answer.

(1)

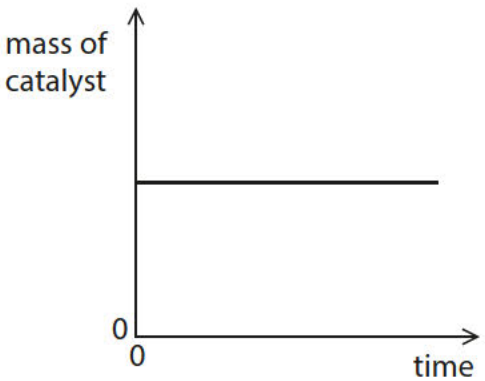
☐ **A**



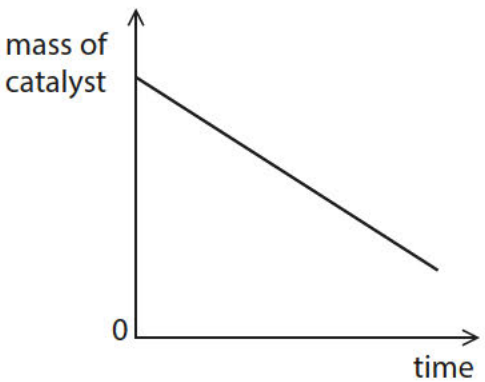
☐ **B**



☐ **C**



☐ **D**



(ii) The decomposition of hydrogen peroxide, H_2O_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)

3 (a) A student investigated the rate of a reaction.
The student investigated the reaction between zinc and dilute sulfuric acid.
The products are zinc sulfate, $ZnSO_4$, and hydrogen.

(i) Write the balanced equation for this reaction.

(2)

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*(ii) The student carried out two experiments.
The same mass of zinc and the same sized pieces of zinc were used in each experiment.

The results are shown in the table.

	experiment 1	**experiment 2**
concentration of sulfuric acid / mol dm^{-3}	0.5	1.5
temperature / °C	20	40
rate of reaction	slow	fast

Evaluate these results, explaining the reasons why the rate of reaction in experiment 2 is faster than the rate of reaction in experiment 1.
In your answer you should refer to the frequency and energy of collisions between particles.

(6)

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(b) Zinc is reacted with copper sulfate solution.
The equation for the reaction is

$$Zn(s) + CuSO_4(aq) \rightarrow ZnSO_4(aq) + Cu(s)$$

(i) What type of reaction is this?

(1)

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

☒ **A** decomposition

☒ **B** displacement

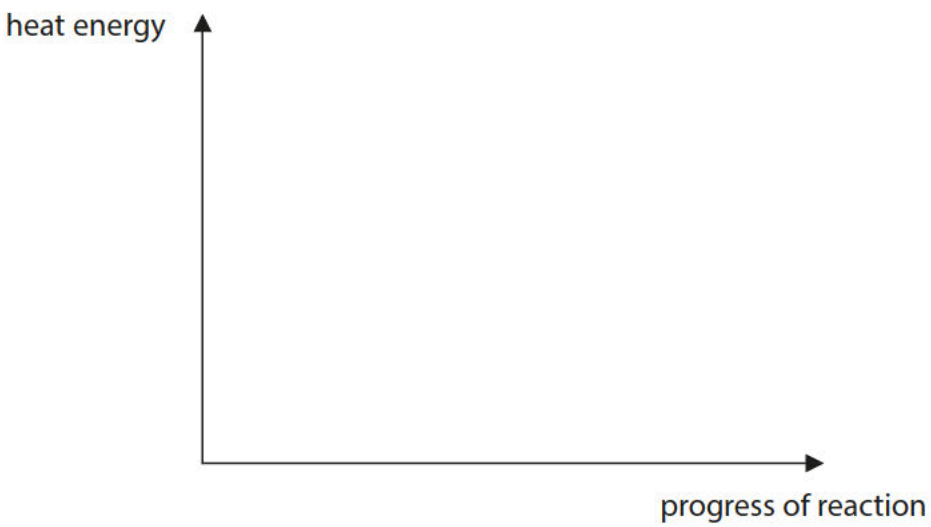
☒ **C** dissolving

☒ **D** neutralisation

(ii) This reaction is exothermic.

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

(2)



(Total for Question 3 = 11 marks)

4 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)

$CaCO_3 + HCl \rightarrow$ ..... + ... + ...

(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.

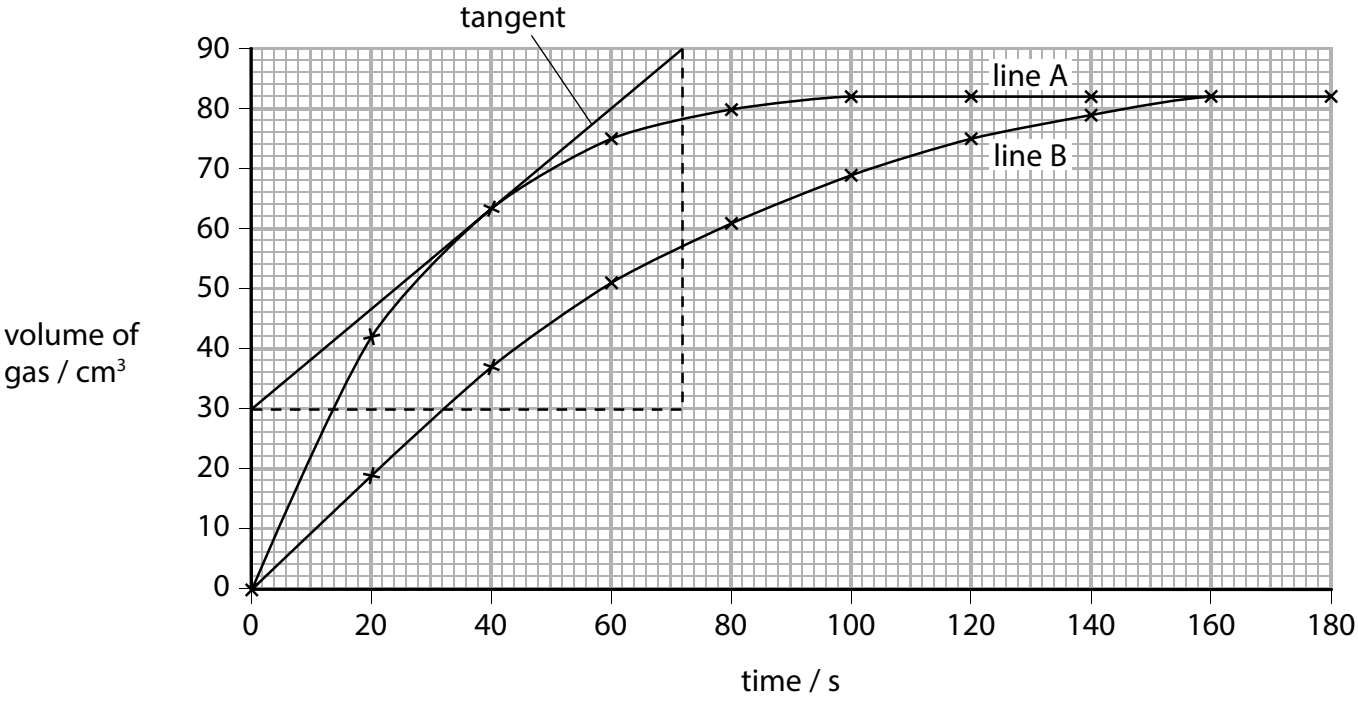


Figure 8

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

(1)

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

Calculate the rate of reaction at this point.

(2)

rate of reaction = ... $cm^3 s^{-1}$

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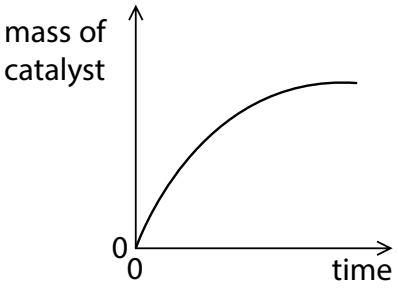
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(d) The decomposition of hydrogen peroxide is catalysed by adding a small amount of manganese(IV) oxide.

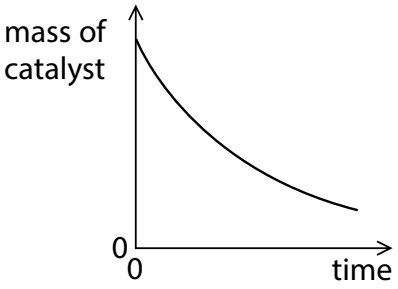
Which of these graphs shows the mass of the catalyst as the reaction takes place?

(1)

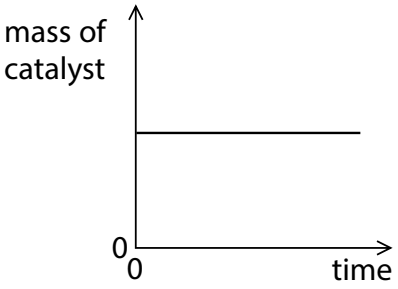
☒ **A**



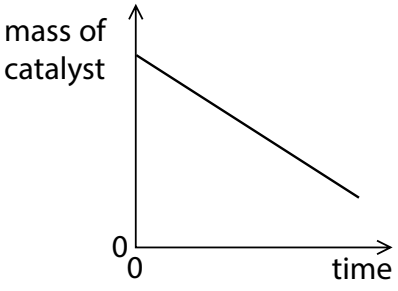
☒ **B**



☒ **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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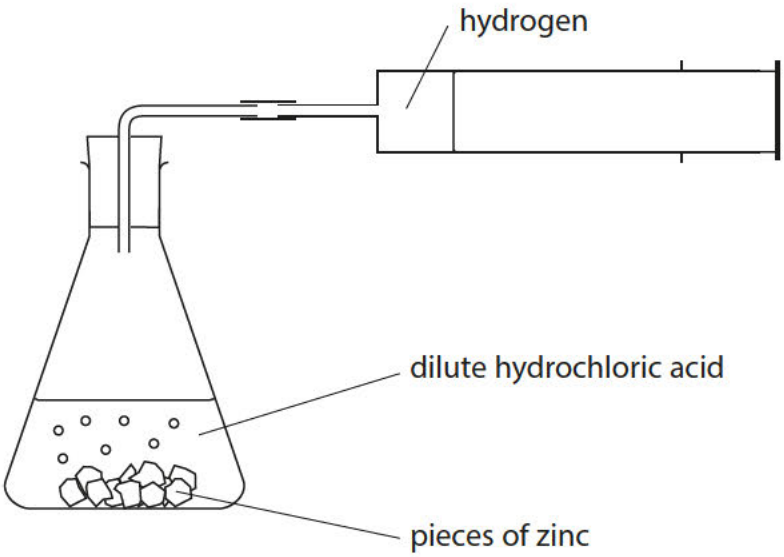
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(Total for Question 4 = 11 marks)

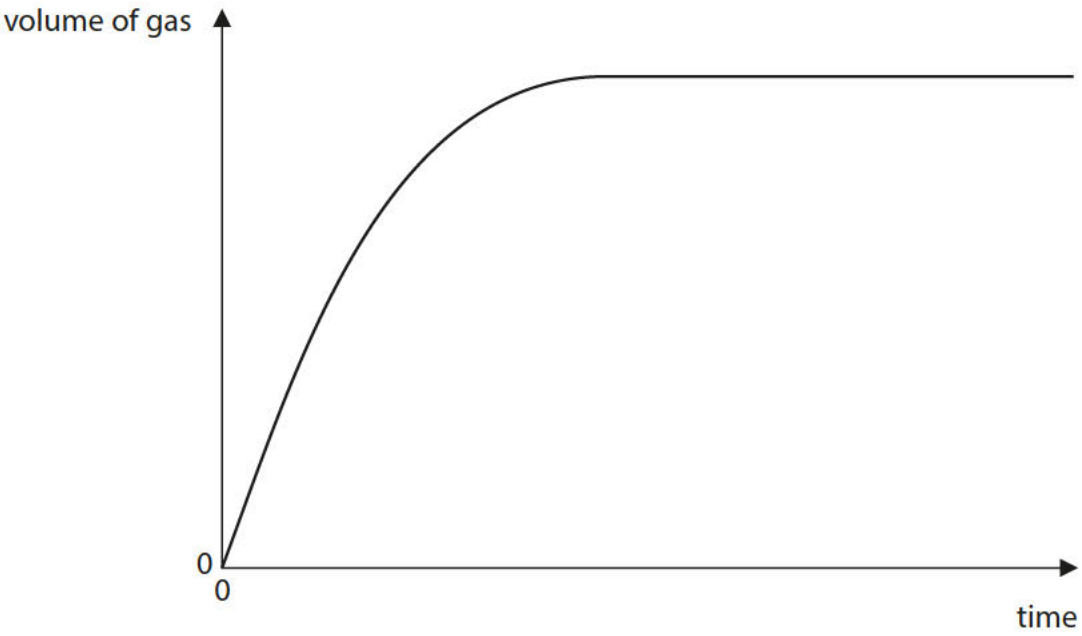
5 (a) Zinc is a metal.

Zinc reacts with dilute hydrochloric acid to produce zinc chloride and hydrogen.

Edward used this apparatus to investigate the speed of the reaction between zinc and dilute hydrochloric acid.



(i) Edward's results for 50 °C are shown on the graph.



Sketch a line on the graph to show the results that Edward should expect to obtain if he carried out the experiment to completion at 30 °C.

(2)

(ii) When zinc powder is used, instead of larger pieces of zinc, the reaction is faster.

Explain, using ideas about particles, why the reaction is faster when zinc powder is used.

(2)

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(iii) Balance the equation for the reaction of zinc with dilute hydrochloric acid by putting a number in the space provided.

(1)

$$Zn + \text{.....} HCl \rightarrow ZnCl_2 + H_2$$

(iv) The reaction between zinc and dilute hydrochloric acid is exothermic.

Explain, in terms of breaking and forming bonds, why this reaction is exothermic.

(3)

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(b) Catalysts are added to some reactions.

State the effect of catalysts on reactions.

(1)

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(Total for Question 5 = 9 marks)