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

One mole of the following substances is dissolved in 1 dm^3 of water.

Which solution contains the greatest number of ions?

(1)

☒ **A** ammonium sulfate, $(NH_4)_2SO_4$

☒ **B** iron(III) chloride, $FeCl_3$

☒ **C** magnesium nitrate, $Mg(NO_3)_2$

☒ **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^{-3}.

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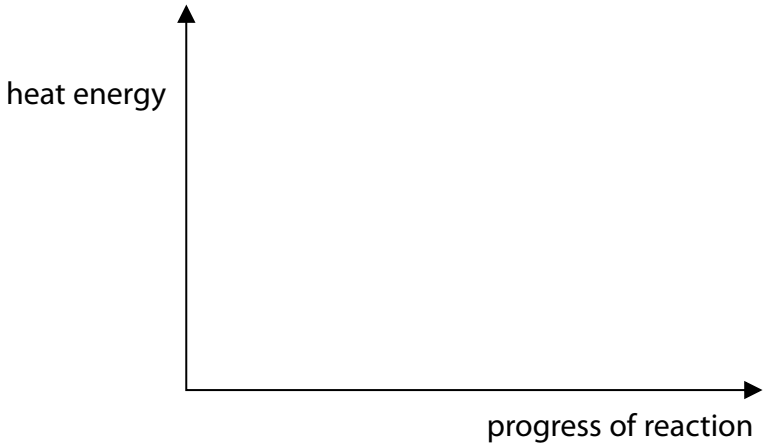
(c) Hydrogen reacts with chlorine to form hydrogen chloride.

$$H_2(g) + Cl_2(g) \rightarrow 2HCl(g)$$

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^{-1}
H—H	436
Cl—Cl	243
H—Cl	432

Figure 13

Hydrogen reacts with chlorine to form hydrogen chloride.

$$H_2(g) + Cl_2(g) \rightarrow 2HCl(g)$$

Calculate the energy change, in kJ mol^{-1}, for the reaction of 1 mol of hydrogen gas, H_2, with 1 mol of chlorine gas, Cl_2, to form 2 mol of hydrogen chloride gas, HCl.

(4)

energy change = ... kJ mol^{-1}

(Total for Question 1 = 12 marks)

2 (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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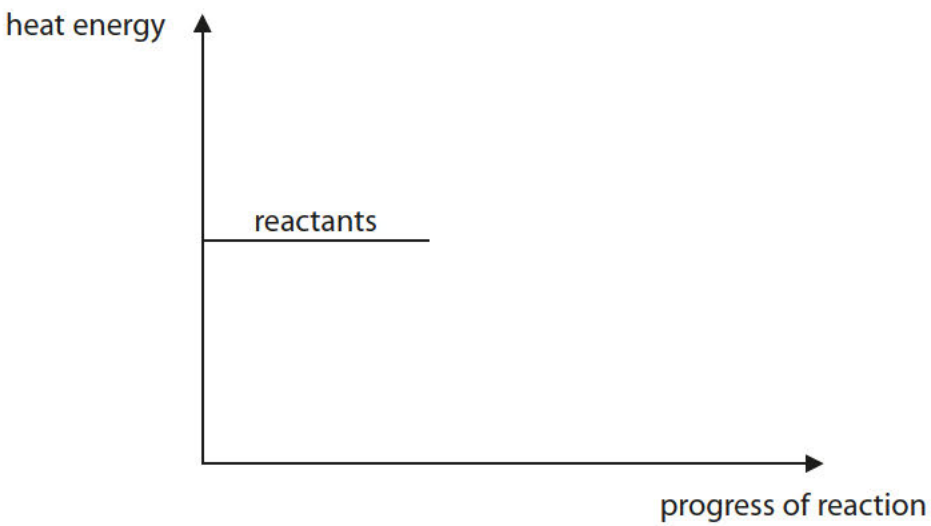
(b) When zinc reacts with copper sulfate solution, copper and zinc sulfate solution are formed.

$$Zn + CuSO_4 \rightarrow Cu + ZnSO_4$$

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)

	bonds broken	bonds formed
☐ **A**	heat energy is released	heat energy is released
☐ **B**	heat energy is required	heat energy is required
☐ **C**	heat energy is released	heat energy is required
☐ **D**	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)

(Total for Question 2 = 11 marks)

3 (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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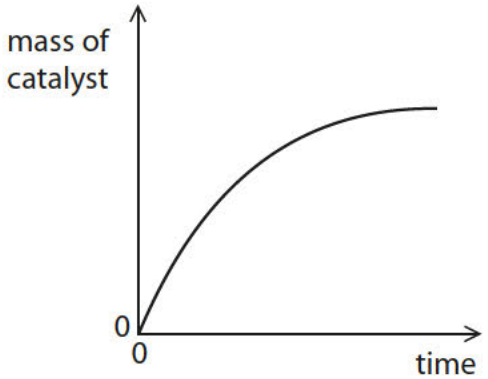
(c) (i) The rate of decomposition of hydrogen peroxide can be increased by adding a catalyst.

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

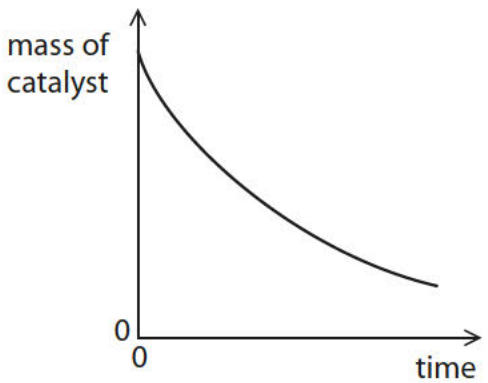
Put a cross (☒) in the box next to your answer.

(1)

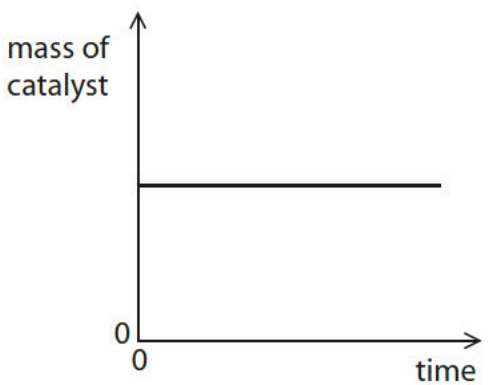
☒ **A**



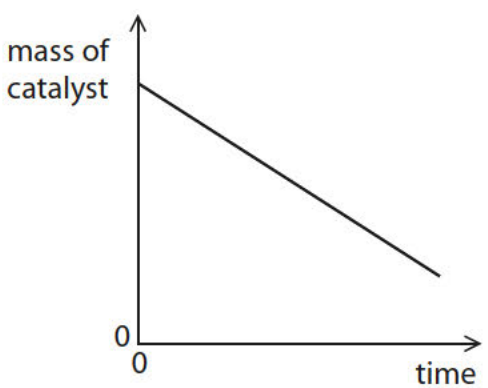
☒ **B**



☒ **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 3 = 8 marks)

4 (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

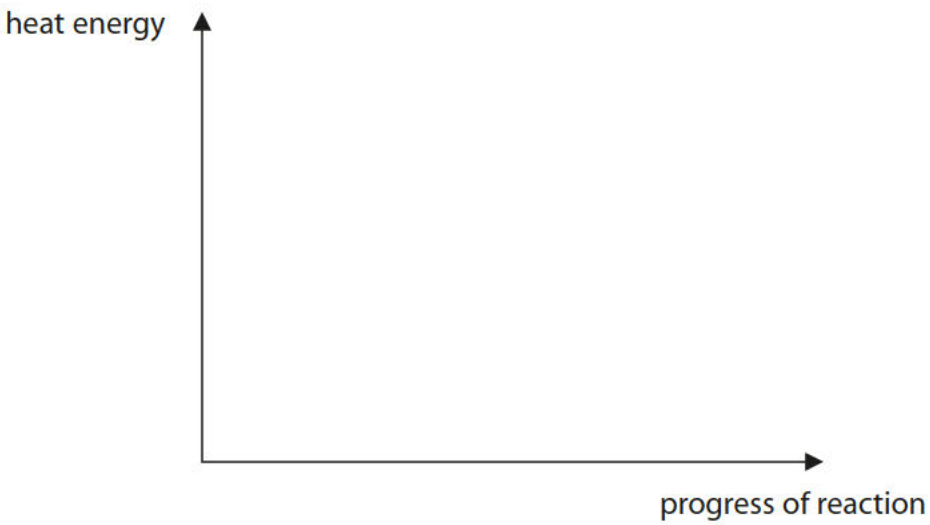
☒ **C** dissolving

☒ **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 4 = 11 marks)