AQA GCSE CHEMISTRY (HIGHER) · 8462

CHEMISTRY



EXAM QUESTION PACK

4.5.1 EXOTHERMIC AND ENDOTHERMIC REACTIONS (PACK 1)

SCORE	PERCENTAGE
/377	%

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Q1.

A student investigated the temperature change in displacement reactions between metals and copper sulfate solution.

This is the method used.

1. Measure 50 cm^3 of the copper sulfate solution into a polystyrene cup.
2. Record the starting temperature of the copper sulfate solution.
3. Add the metal and stir the solution.
4. Record the highest temperature the mixture reaches.
5. Calculate the temperature increase for the reaction.
6. Repeat steps 1-5 with different metals.

(a) Draw **one** line from each type of variable to the name of the variable in the investigation.

Type of variable	Name of variable in the investigation
	Concentration of solution
Dependent variable	Particle size of solid
	Temperature change
Independent variable	Type of metal
	Volume of solution

(2)

(b) The student used a polystyrene cup and not a glass beaker.

Why did this make the investigation more accurate?

Tick **one** box.

Glass is breakable ☐

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Glass is transparent ☐

Polystyrene is a better insulator ☐

Polystyrene is less dense ☐

(1)

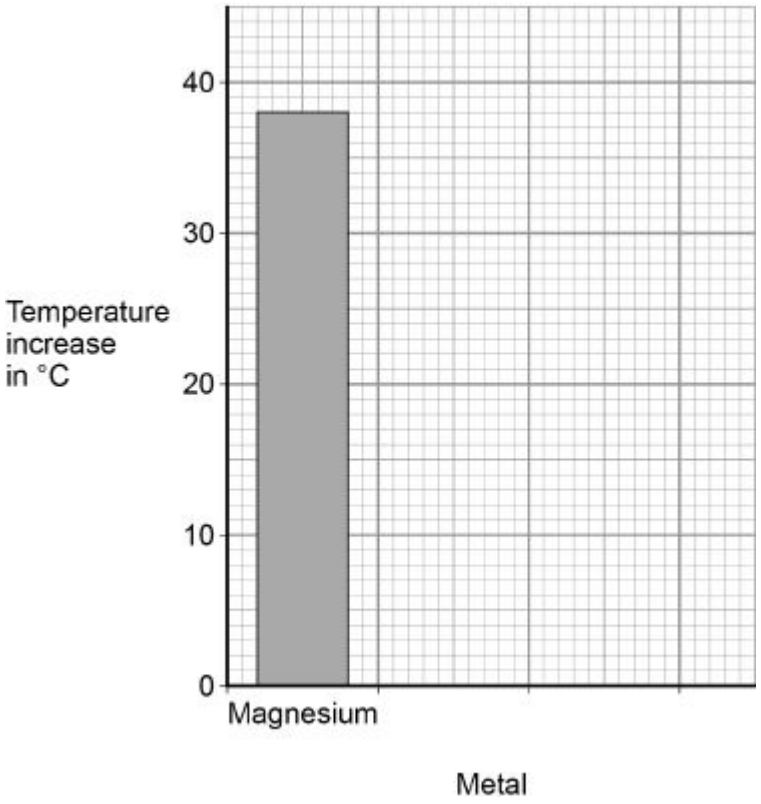
The table below shows the student's results.

Metal	**Temperature increase in °C**
Magnesium	38
Nickel	8
Zinc	16

(c) Complete **Figure 1**.

Use data from the table above.

Figure 1



(2)

(d) The student concluded that the reactions between the metals and copper sulfate solution are endothermic.

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Give **one** reason why this conclusion is **not** correct.

_____

_____

(1)

(e) The temperature increase depends on the reactivity of the metal.

Write the metals magnesium, nickel and zinc in order of reactivity.

Use the table above.

Most reactive _____

_____

Less reactive _____

(1)

(f) **Y** is an unknown metal.

Describe a method to find the position of **Y** in the reactivity series in Question **(e)**

_____

_____

_____

_____

_____

_____

_____

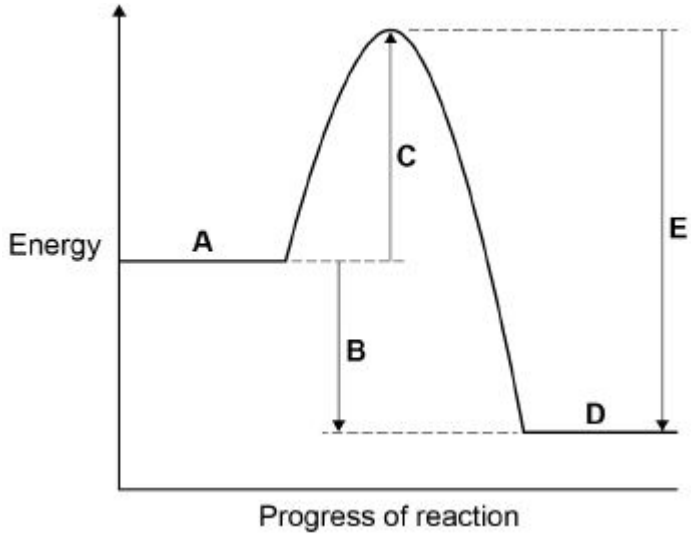
_____

(3)

Figure 2 shows the reaction profile for the reaction between zinc and copper sulfate solution.

Figure 2

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(g) Which letter represents the products of the reaction?

Tick **one** box.

A		B		C		D		E	

(1)

(h) Which letter represents the activation energy?

Tick **one** box.

A		B		C		D		E	

(1)

(Total 12 marks)

Q2.

A student investigated the temperature change in displacement reactions between metals and copper sulfate solution.

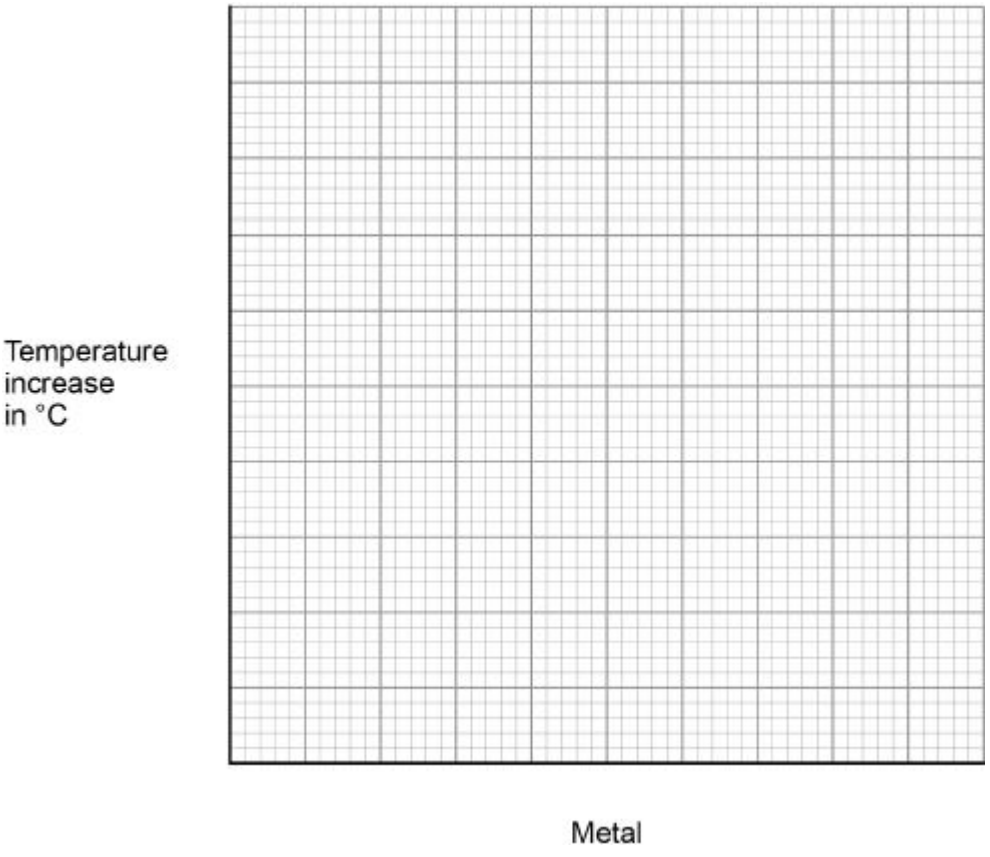
The table below shows the student's results.

Metal	**Temperature increase in °C**
Copper	0
Iron	13
Magnesium	43
Zinc	17

(a) Plot the data from the table above on **Figure 1** as a bar chart.

Figure 1

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(2)

(b) The student concluded that the reactions between the metals and copper sulfate solution are endothermic.

Give **one** reason why this conclusion is **not** correct.

_____

_____

(1)

(c) The temperature change depends on the reactivity of the metal.

The student's results are used to place copper, iron, magnesium and zinc in order of their reactivity.

Describe a method to find the position of an unknown metal in this reactivity series.

Your method should give valid results.

_____

_____

_____

_____

_____

_____

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_____

_____

(4)

(d) Draw a fully labelled reaction profile for the reaction between zinc and copper sulfate solution on **Figure 2**.

Figure 2



(3)

(Total 10 marks)

Q3.

This question is about Group 7 elements.

Chlorine is more reactive than iodine.

(a) Name the products formed when chlorine solution reacts with potassium iodide solution.

_____

_____

(1)

(b) Explain why chlorine is more reactive than iodine.

_____

_____

_____

_____

_____

_____

(3)

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(c) Chlorine reacts with hydrogen to form hydrogen chloride.

Explain why hydrogen chloride is a gas at room temperature.

Answer in terms of structure and bonding.

_____

_____

_____

_____

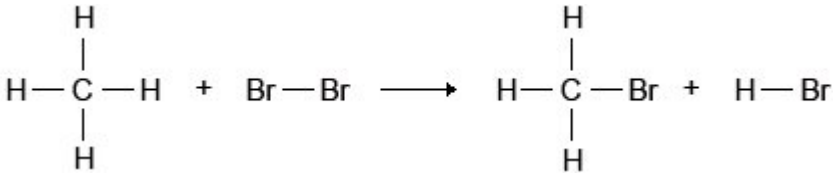
_____

_____

(3)

(d) Bromine reacts with methane in sunlight.

The diagram below shows the displayed formulae for the reaction of bromine with methane.



The table below shows the bond energies and the overall energy change in the reaction.

	C—H	**Br—Br**	**C—Br**	**H—Br**	**Overall energy change**
Energy in kJ/mol	412	193	**X**	366	−51

Calculate the bond energy **X** for the C—Br bond.

Use the diagram and the table above.

_____

_____

_____

_____

_____

_____

_____

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Bond energy **X** = _____ kJ/mol

(4)

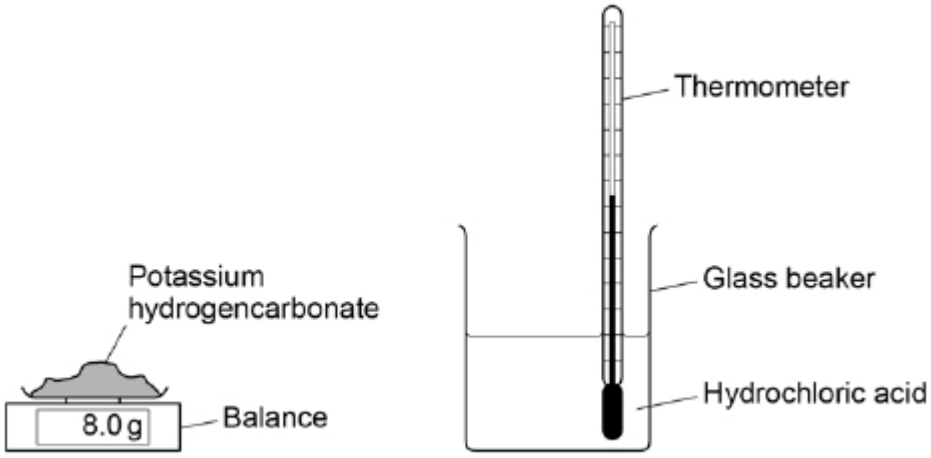
(Total 11 marks)

Q4.

A student investigated the energy change occurring in the endothermic reaction between potassium hydrogencarbonate and hydrochloric acid.

Figure 1 shows the apparatus used.

Figure 1



This is the method used.

1. Measure 50 cm^3 hydrochloric acid into a glass beaker.
2. Measure 1.0 g of potassium hydrogencarbonate.
3. Add the potassium hydrogencarbonate to the hydrochloric acid.
4. Stir until all the potassium hydrogencarbonate has reacted.
5. Record the lowest temperature reached.
6. Repeat steps 1–5 two more times.
7. Repeat steps 1–6 with different masses of potassium hydrogencarbonate.

(a) Which is the most suitable apparatus to use to measure 50 cm^3 of hydrochloric acid?

Tick (✔) **one** box.

Balance ☐

Conical flask ☐

Gas syringe ☐

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Measuring cylinder ☐

(1)

(b) The student used a glass beaker for the reaction.

Suggest **one** change to the apparatus that would improve the accuracy of the results.

Give a reason for your answer.

_____

_____

_____

_____

(2)

(c) Which **two** variables should the student keep the same to make this a fair test?

Tick **two** boxes.

Mass of potassium hydrogencarbonate ☐

Same balance ☐

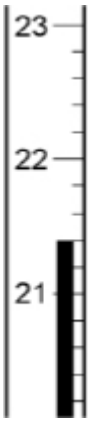
Same thermometer ☐

Starting temperature of hydrochloric acid ☐

Volume of hydrochloric acid ☐

(2)

(d) **Figure 2** shows part of the thermometer used to measure the temperature.



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What is the temperature reading on the thermometer?

Temperature = _____ °C

(1)

The table shows a set of results.

	Test 1	**Test 2**	**Test 3**
Lowest temperature in °C	16.1	15.8	15.9

(e) What is the range of the lowest temperature?

From _____ °C to _____ °C

(1)

(f) Calculate the mean lowest temperature.

Use the table above.

_____

_____

_____

Mean lowest temperature = _____ °C

(2)

(g) How do the results show that the reaction is endothermic?

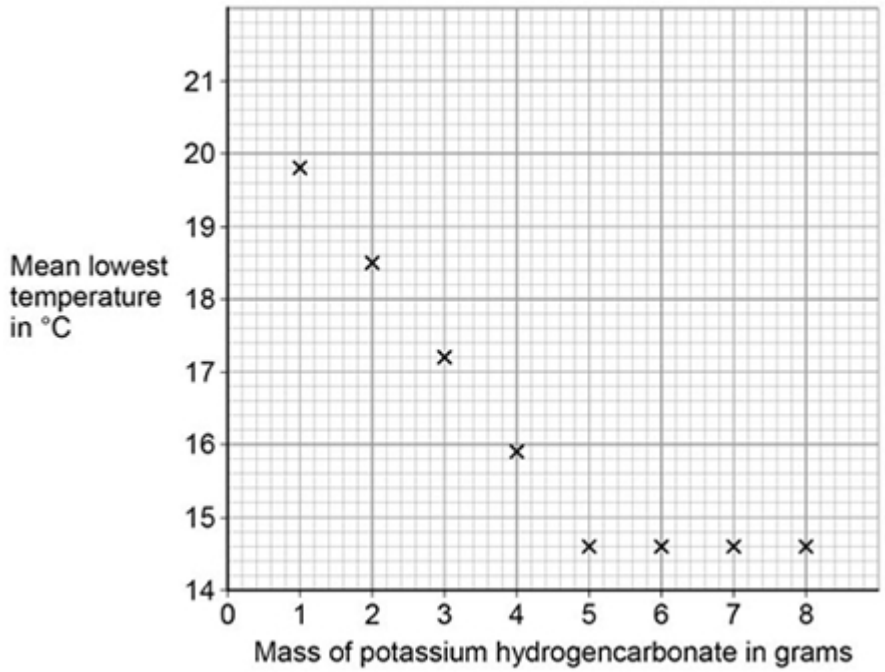
_____

_____

(1)

The graph shows the student's results.

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(h) Draw **two** straight lines of best fit on the graph above.

(2)

(i) Describe how the lowest temperature changes as the mass of potassium hydrogencarbonate added increases.

_____

_____

_____

_____

_____

_____

(3)

(Total 15 marks)

Q5.

Some students investigated the energy changes occurring in the reaction between potassium hydrogencarbonate and hydrochloric acid.

The equation for the reaction is:

$$KHCO_3(s) + HCl(aq) \longrightarrow KCl(aq) + CO_2(g) + H_2O(l)$$

This is the method used.

1. Measure 50 cm^3 hydrochloric acid into a glass beaker.
2. Measure the temperature of the hydrochloric acid.
3. Measure a given mass of potassium hydrogencarbonate.
4. Add the potassium hydrogencarbonate to the hydrochloric acid.

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5. Stir until all the potassium hydrogencarbonate has reacted.
6. Record the lowest temperature reached.
7. Repeat three more times, using the same mass of potassium hydrogencarbonate.

Each student used a different mass of potassium hydrogencarbonate.

(a) The method described will not give very accurate results.

Suggest **one** change to the apparatus that would improve the accuracy of the results.

Give a reason for your answer.

_____

_____

_____

_____

(2)

(b) The students controlled the volume of the hydrochloric acid.

Give **one** other control variable the students should use.

_____

_____

(1)

(c) The table shows one student's results.

	Trial 1	**Trial 2**	**Trial 3**	**Trial 4**
Initial temperature in °C	21.2	21.1	21.0	21.1
Final temperature in °C	15.6	15.4	15.6	16.6
Temperature decrease in °C	5.6	5.7	5.4	4.5

Calculate the mean temperature decrease for the results shown in the table above.

Ignore any anomalous results.

Give your answer to 1 decimal place.

Give the uncertainty in your answer.

_____

_____

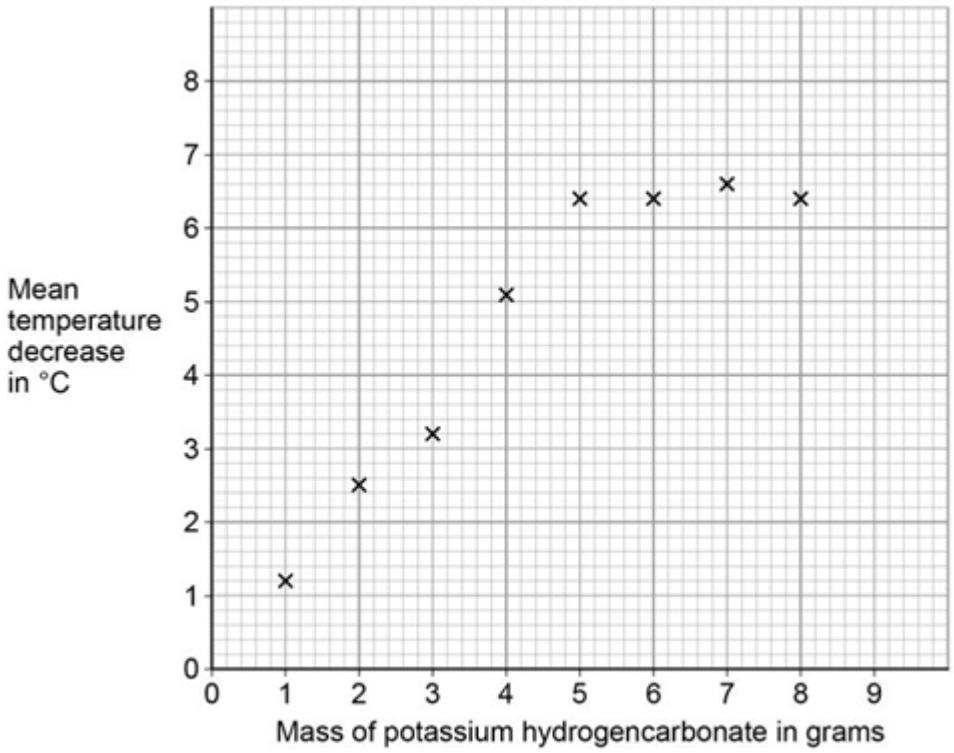
_____

Mean = _____ °C ± _____ °C

(3)

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The graph below shows the students' results.



(d) Draw **two** intersecting straight lines of best fit on the graph above.

(2)

(e) Explain why the graph has this shape.

Use data from the graph.

_____

_____

_____

_____

_____

_____

(3)

(f) Suggest a possible reason for the anomalous points.

Do **not** include errors in measuring.

_____

_____

(1)

(Total 12 marks)

Q6.

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Cells contain chemicals which react to produce electricity.

(a) Why can a rechargeable cell be recharged?

_____

_____

(1)

(b) Give **two** factors that affect the voltage produced by a cell.

1. _____

2. _____

(2)

(c) Balance the half-equation for the reaction occurring at an electrode in one type of hydrogen fuel cell.

$$H_2 \quad + \quad OH^- \quad \longrightarrow \quad H_2O \quad + \quad e^-$$

(1)

(d) Why is the fuel cell in Question (c) described as an alkaline fuel cell?

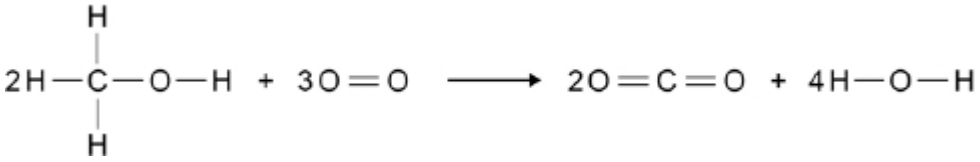
_____

_____

(1)

(e) Another type of fuel cell uses methanol instead of hydrogen.

The diagram represents the reaction in this fuel cell.



The table shows the bond energies for the reaction.

	C–H	**C–O**	**O–H**	**O=O**	**C=O**
Bond energy in kJ / mol	412	360	464	498	805

Calculate the overall energy change for the reaction.

Use the diagram and the table above.

_____

_____

_____

_____

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_____

_____

Overall energy change = _____ kJ / mol

(3)

(Total 8 marks)

Q7.

The figure below shows magnesium burning in air.



© Charles D Winters/Science Photo Library

(a) Look at the figure above.

How can you tell that a chemical reaction is taking place?

_____

_____

(1)

(b) Name the product from the reaction of magnesium in the figure.

_____

(1)

(c) The magnesium needed heating before it would react.

What conclusion can you draw from this?

Tick **one** box.

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The reaction is reversible ☐

The reaction has a high activation energy ☐

The reaction is exothermic ☐

Magnesium has a high melting point ☐

(1)

(d) A sample of the product from the reaction in the figure above was added to water and shaken.

Universal indicator was added.

The universal indicator turned blue.

What is the pH value of the solution?

Tick **one** box.

1 ☐

4 ☐

7 ☐

9 ☐

(1)

(e) Why are nanoparticles effective in very small quantities?

Tick **one** box.

They are elements ☐

They are highly reactive ☐

They have a low melting point ☐

They have a high surface area to volume ratio ☐

(1)

(f) Give **one** advantage of using nanoparticles in sun creams.

_____

_____

(1)

(g) Give **one** disadvantage of using nanoparticles in sun creams.

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_____

_____

(1)

(h) A coarse particle has a diameter of 1×10^{-6} m.
A nanoparticle has a diameter of 1.6×10^{-9} m.

Calculate how many times bigger the diameter of the coarse particle is than the diameter of the nanoparticle.

_____

_____

_____

_____

(2)

(Total 9 marks)

Q8.

This question is about the reaction of ethene and bromine.

The equation for the reaction is:

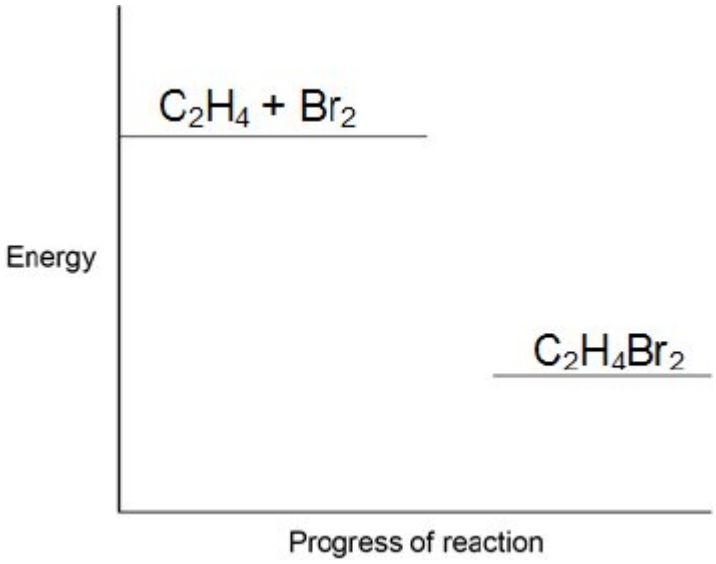
$$C_2H_4 + Br_2 \rightarrow C_2H_4Br_2$$

(a) Complete the reaction profile in **Figure 1**.

Draw labelled arrows to show:

- The energy given out (ΔH)
- The activation energy.

Figure 1



(3)

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(b) When ethene reacts with bromine, energy is required to break covalent bonds in the molecules.

Explain how a covalent bond holds two atoms together.

_____

_____

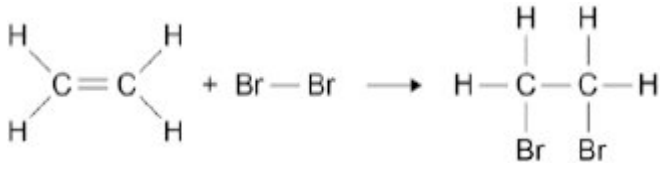
_____

_____

(2)

(c) **Figure 2** shows the displayed formulae for the reaction of ethene with bromine.

Figure 2



The bond enthalpies and the overall energy change are shown in the table below.

	C=C	**C–H**	**C–C**	**C–Br**	**Overall energy change**
Energy in kJ / mole	612	412	348	276	−95

Use the information in the table above and **Figure 2** to calculate the bond energy for the Br–Br bond.

_____

_____

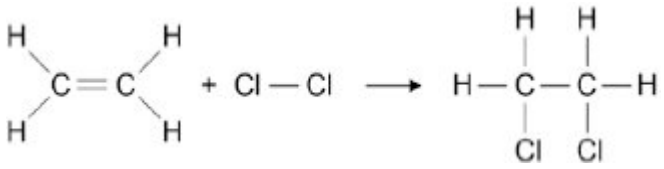
_____

Bond energy _____ kJ / mole

(3)

(d) **Figure 3** shows the reaction between ethene and chlorine and is similar to the reaction between ethene and bromine.

Figure 3



"The more energy levels (shells) of electrons an atom has, the weaker the covalent bonds that it forms."

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Use the above statement to predict and explain how the overall energy change for the reaction of ethene with chlorine will differ from the overall energy change for the reaction of ethene with bromine.

_____

_____

_____

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_____

_____

_____

(6)

(Total 14 marks)

Q9.

This question is about hydrocarbons.

(a) Most of the hydrocarbons in crude oil are alkanes.

(i) Large alkane molecules can be cracked to produce more useful molecules.

The equation shows the cracking of dodecane.

$$\underset{\text{dodecane}}{C_{12}H_{26}} \longrightarrow \underset{\text{butane}}{C_4H_{10}} + \underset{\text{hexene}}{C_6H_{12}} + \underset{\text{ethene}}{C_2H_4}$$

Give **two** conditions used to crack large alkane molecules.

1. _____

2. _____

(2)

(ii) The products hexene and ethene are alkenes.

Complete the sentence.

When alkenes react with bromine water the colour changes

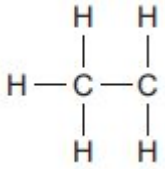
from orange to _____ .

(1)

(iii) Butane (C_4H_{10}) is an alkane.

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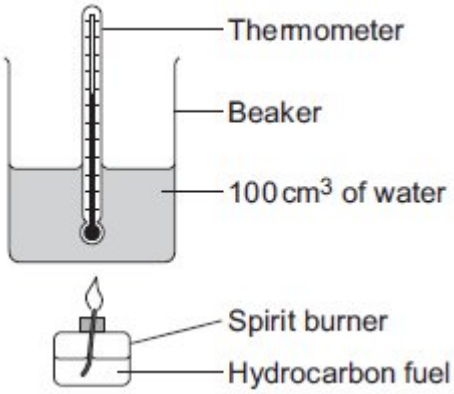
Complete the displayed structure of butane.



(1)

(b) A group of students investigated the energy released by the combustion of four hydrocarbon fuels.

The diagram below shows the apparatus used.



Each hydrocarbon fuel was burned for two minutes.

Table 1 shows the students' results.

Table 1

	After two minutes				
Name and formula of hydrocarbon fuel	**Mass of fuel used in g**	**Temperature increase of water in °C**	**Energy released by fuel in kJ**	**Energy released by 1.0 g of fuel in kJ**	**Relative amount of smoke in the flame**
Hexane, C_6H_{14}	0.81	40	16.80	20.74	very little smoke
Octane, C_8H_{18}	1.10	54	22.68	20.62	some smoke
Decane, $C_{10}H_{22}$	1.20	58	24.36		smoky
Dodecane, $C_{12}H_{26}$	1.41	67	28.14	19.96	very smoky

(i) Calculate the energy released by 1.0 g of decane in kJ.

_____

_____

Energy released = _____ kJ

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(2)

(ii) Suggest **one** improvement to the apparatus, or the use of the apparatus, that would make the temperature increase of the water for each fuel more accurate.

Give a reason why this is an improvement.

_____

_____

_____

(2)

(iii) The students noticed that the bottom of the beaker became covered in a black substance when burning these fuels.

Name this black substance.

Suggest why it is produced.

_____

_____

_____

_____

(2)

(iv) A student concluded that hexane is the best of the four fuels.

Give **two** reasons why the results in **Table 2** support this conclusion.

1. _____

_____

2. _____

_____

(2)

(c) **In this question you will be assessed on using good English, organising information clearly and using specialist terms where appropriate.**

Most car engines use petrol as a fuel.

- Petrol is produced from the fractional distillation of crude oil.
- Crude oil is a mixture of hydrocarbons.
- Sulfur is an impurity in crude oil.

Car engines could be developed to burn hydrogen as a fuel.

- Hydrogen is produced from natural gas.

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- Natural gas is mainly methane.

Table 2 shows information about petrol and hydrogen.

Table 2

	Petrol	**Hydrogen**
State of fuel at room temperature	Liquid	Gas
Word equation for combustion of the fuel	petrol + oxygen ⟶ carbon dioxide + water	hydrogen + oxygen ⟶ water
Energy released from combustion of 1 g of the fuel	47 kJ	142 kJ

Describe the **advantages** and **disadvantages** of using hydrogen instead of petrol in car engines.

Use the information given and your knowledge and understanding to answer this question.

(6)

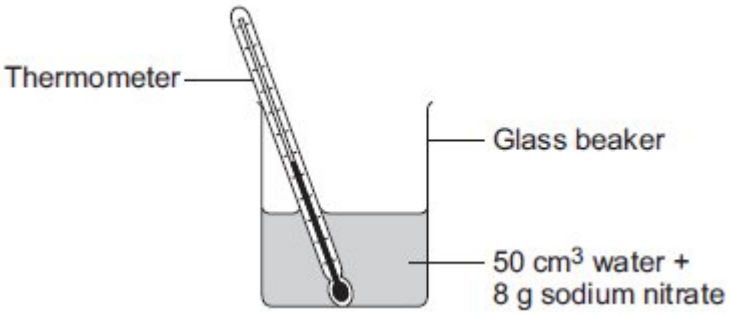
(Total 18 marks)

Q10.

This question is about temperature changes.

(a) A student investigated the temperature change when 8 g of sodium nitrate dissolves in 50 cm^3 of water.

The diagram below shows the apparatus the student used.



The student did the experiment five times.
Table 1 shows the results.

Table 1

Experiment	**Decrease in temperature of water in °C**
1	5.9

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2	5.7
3	7.2
4	5.6
5	5.8

(i) Calculate the mean decrease in temperature.
Do not use the anomalous result in your calculation.

_____

_____

Mean decrease in temperature = _____ °C

(2)

(ii) Suggest **one** change in the apparatus in the diagram above which would improve the accuracy of the results.
Give a reason for your answer.

_____

_____

_____

_____

(2)

(b) The student investigated the temperature change when different masses of sodium carbonate were added to 50 cm^3 of water at 20 °C.

Table 2 below shows the results.

Table 2

Mass of sodium carbonate in g	**Final temperature of solution in °C**
2.0	21.5
4.0	23.0
6.0	24.5
8.0	26.0
10.0	26.6
12.0	26.6
14.0	26.6

Describe the relationship between the mass of sodium carbonate added and the final temperature of the solution.

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Use values from **Table 2** in your answer.

_____

_____

_____

_____

_____

_____

(3)

(Total 7 marks)

Q11.

This question is about ammonia and fertilisers.

(a) Ammonia is produced by a reversible reaction.

The equation for the reaction is:

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

Complete the sentence.

The forward reaction is exothermic, so the reverse reaction

is _____

(1)

(b) Calculate the percentage by mass of nitrogen in ammonia (NH_3).
Relative atomic masses (A_r): H = 1; N = 14
You **must** show how you work out your answer.

_____

_____

_____

_____

_____

_____

Percentage by mass of nitrogen = _____ %

(3)

(c) A neutral solution can be produced when ammonia reacts with an acid.

(i) Give the pH of a neutral solution.

pH _____

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(1)

(ii) Which of these ionic equations shows a neutralisation reaction?

Tick (✔) **one** box.

$H^+ + OH^- \longrightarrow H_2O$ ☐

$NH_4^+ + OH^- \longrightarrow NH_4OH$ ☐

$H^+ + Cl^- \longrightarrow HCl$ ☐

$H^+ + H_2O \longrightarrow H_3O^+$ ☐

(1)

(iii) Name the salt produced when ammonia reacts with hydrochloric acid.

_____

(1)

(d) **In this question you will be assessed on using good English, organising information clearly and using specialist terms where appropriate.**

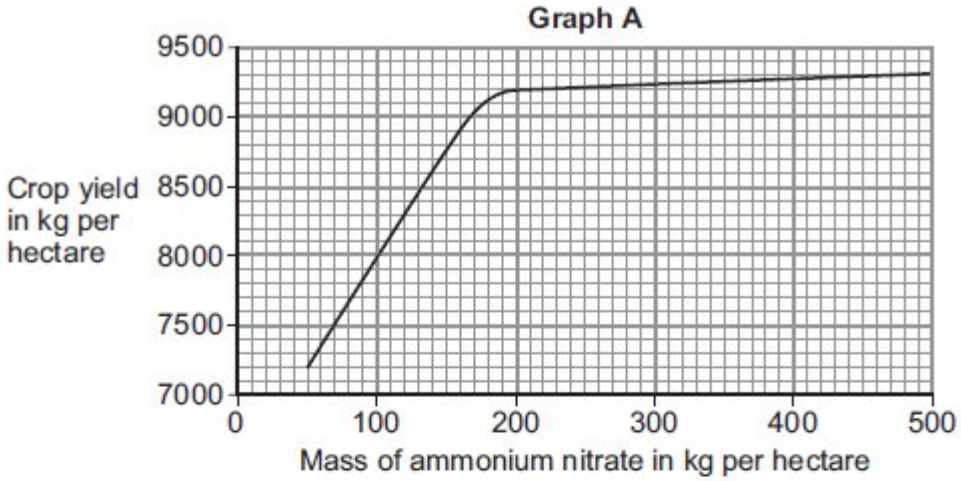
Farmers use ammonium nitrate as a fertiliser for crops.

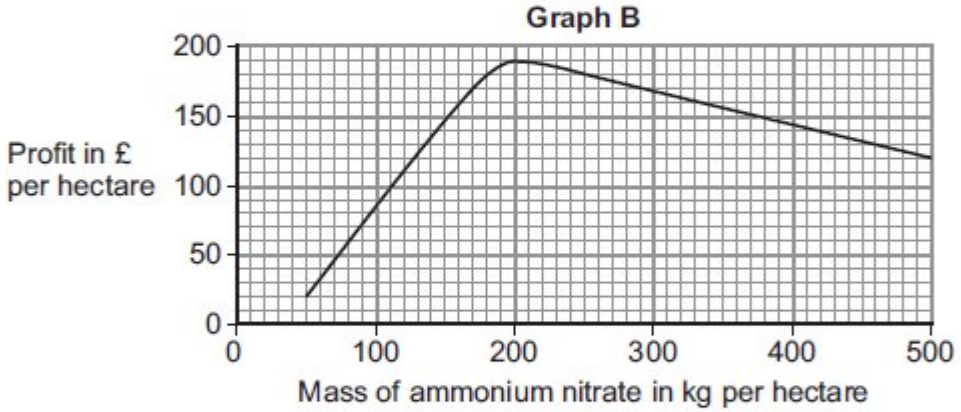
Rainwater dissolves ammonium nitrate in the soil.

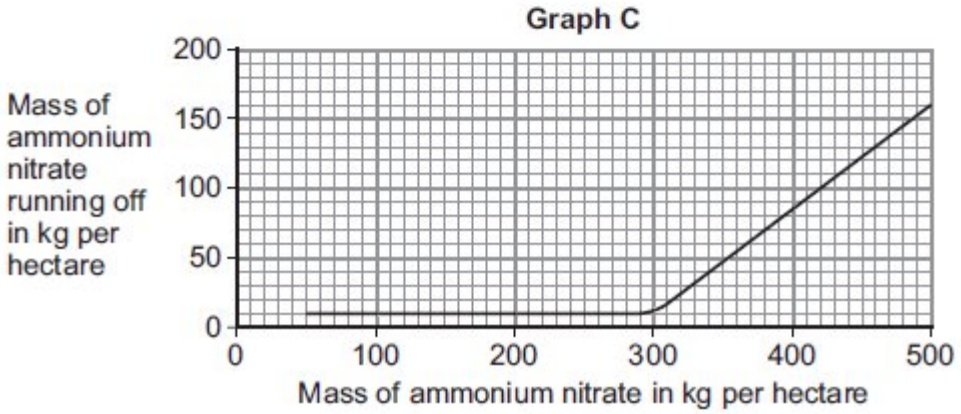
Some of the dissolved ammonium nitrate runs off into rivers and lakes.

The graphs **A**, **B** and **C** below show information about the use of ammonium nitrate as a fertiliser. A hectare is a measurement of an area of land.

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Suggest how much ammonium nitrate farmers should use per hectare.

Give reasons for your answer.

Use information from graphs **A**, **B** and **C**.

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_____

_____

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(6)

(Total 13 marks)

Q12.

This question is about energy changes in chemical reactions.

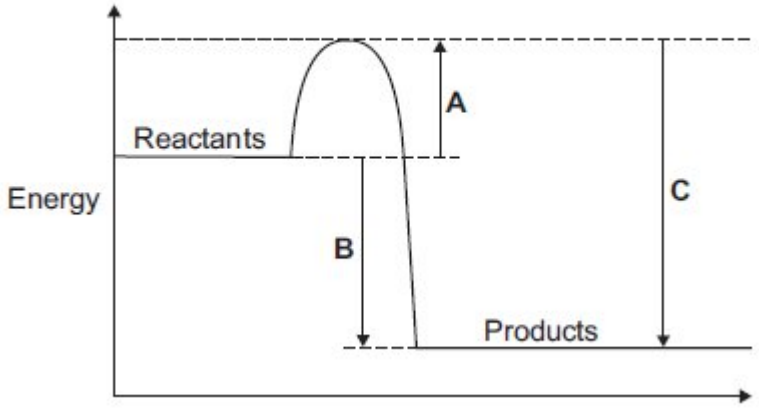
(a) Complete the word equation for the combustion of hydrogen.

hydrogen + oxygen ⟶ _____

(1)

(b) **Figure 1** shows a simple energy level diagram.

Figure 1



(i) Which arrow, **A**, **B** or **C**, shows the activation energy?

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Tick (✔) **one** box.

A ☐

B ☐

C ☐

(1)

(ii) What type of reaction is shown by the energy level diagram in **Figure 1**?
Give a reason for your answer.

Type of reaction _____

Reason _____

_____

(2)

(iii) For a reaction, the value of **A** is 1370 kJ and **C** is 3230 kJ.
Calculate the value of **B**.

_____

_____

B = _____ kJ

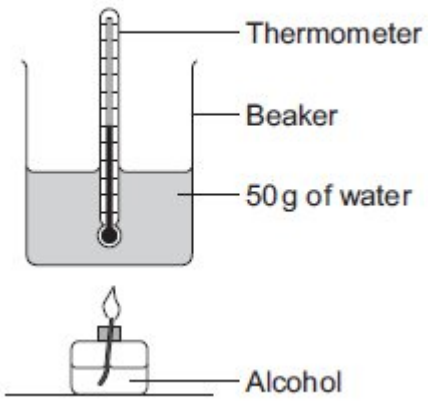
(1)

(c) Alcohols are used as fuels.

A group of students investigated the amount of energy released when different alcohols are burned.

The students used the apparatus shown in **Figure 2**.

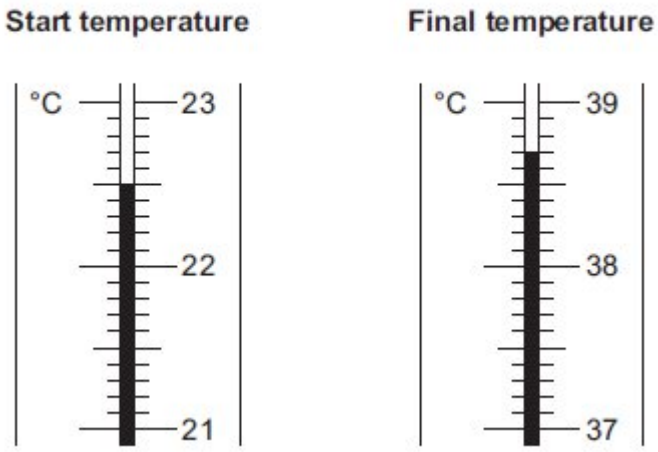
Figure 2



(i) **Figure 3** shows the start temperature and the final temperature of the water.

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Figure 3



Write the start temperature and the final temperature of the water in **Table 1**.
Work out the increase in temperature to complete **Table 1**.

Table 1

Start temperature of the water in °C	
Final temperature of the water in °C	
Increase in temperature in °C	

(3)

(ii) The students worked out the heat energy released by burning 1 g of each alcohol.
The students used the equation:

Heat energy released = m × 4.2 × increase in temperature

Look at **Figure 2**. What is the value of m?

m = _____ g

(1)

(iii) **Table 2** shows the students' results.

Table 2

Name of alcohol	Number of carbon atoms in one molecule of alcohol	Heat energy released when 1 g of alcohol is burned in kJ
Methanol	1	11.4
Ethanol	2	13.5
Propanol	3	20.1
Butanol	4	16.8
Pentanol	5	17.2

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Which value of heat energy released is anomalous?

_____

(1)

(iv) Look at **Table 2**.
What is the relationship between the number of carbon atoms in one molecule of alcohol and the heat energy released when 1 g of the alcohol is burned?

_____

_____

(1)

(v) The value in a data book for the amount of heat energy released when 1 g of butanol is burned completely is 36.2 kJ.

Suggest two reasons why the students' result for butanol is lower than the data book value.

1. _____

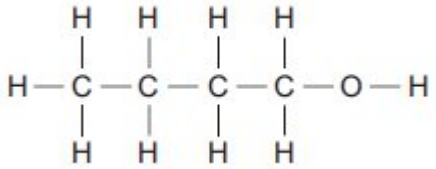
_____

2. _____

_____

(2)

(vi) The displayed structure of butanol is:



What is the functional group of the alcohol?

Tick (✔) **one** box.

— C — C ☐

— C — H ☐

— O — H ☐

(1)

(Total 14 marks)

Q13.

This question is about energy changes in chemical reactions.

(a) Balance the chemical equation for the combustion of methane.

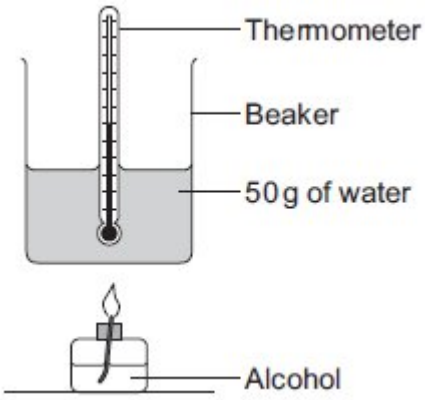
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$$CH_4 \quad + \quad O_2 \quad \longrightarrow \quad CO_2 \quad + \quad H_2O$$

(1)

(b) Alcohols are used as fuels.

A group of students investigated the amount of energy released when an alcohol was burned. The students used the apparatus shown in the diagram below.



In one experiment the temperature of 50 g of water increased from 22.0 °C to 38.4 °C.
The mass of alcohol burned was 0.8 g.

Calculate the heat energy (Q) in joules, released by burning 0.8 g of the alcohol.
Use the equation:

$$Q = m \times c \times \Delta T$$

Specific heat capacity (c) = 4.2 J / g / °C

_____

_____

_____

_____

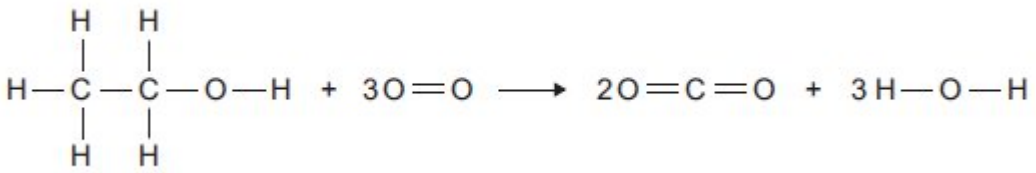
Heat energy (Q) = _____ J

(3)

(c) The chemical equation for the combustion of ethanol is:

$$C_2H_5OH \quad + \quad 3O_2 \quad \longrightarrow \quad 2CO_2 \quad + \quad 3H_2O$$

(i) The equation for the reaction can be shown as:



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Bond	Bond energy in kJ per mole
C — H	413
C — C	347
C — O	358
C ═ O	799
O — H	467
O ═ O	495

Use the bond energies to calculate the overall energy change for this reaction.

_____

_____

_____

_____

_____

_____

Overall energy change = _____ kJ per mole

(3)

(ii) The reaction is exothermic.
Explain why, in terms of bonds broken and bonds formed.

_____

_____

_____

_____

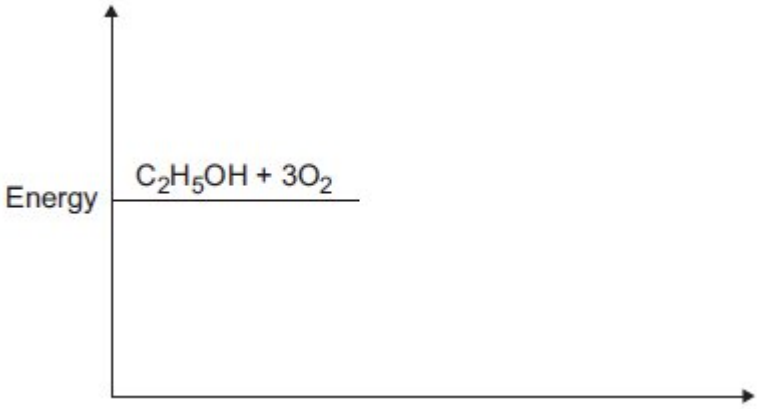
(2)

(iii) Complete the energy level diagram for the combustion of ethanol.

On the completed diagram, label:

- activation energy
- overall energy change.

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(3)
(Total 12 marks)

Q14.

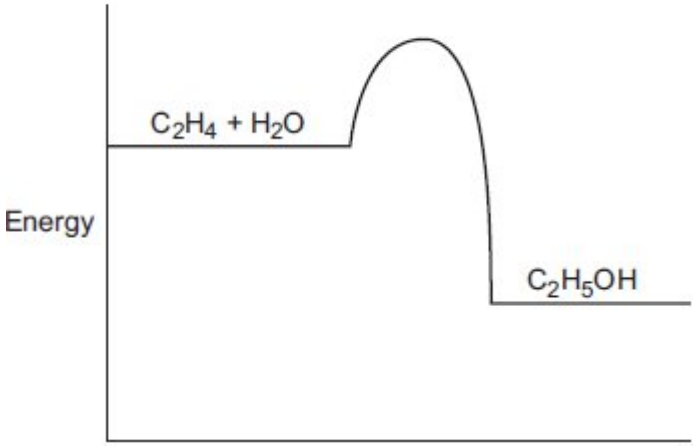
This question is about ethanol.

(a) Ethanol is produced by the reaction of ethene and steam:

$$C_2H_4 + H_2O \longrightarrow C_2H_5OH$$

(i) **Figure 1** shows the energy level diagram for the reaction.

Figure 1



How does the energy level diagram show that the reaction is exothermic?

_____

_____

(1)

(ii) A catalyst is used for the reaction.

Explain how a catalyst increases the rate of the reaction.

_____

_____

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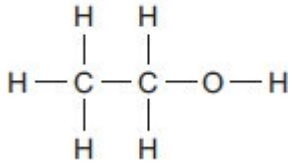
_____

_____

(2)

(b) **Figure 2** shows the displayed structure of ethanol.

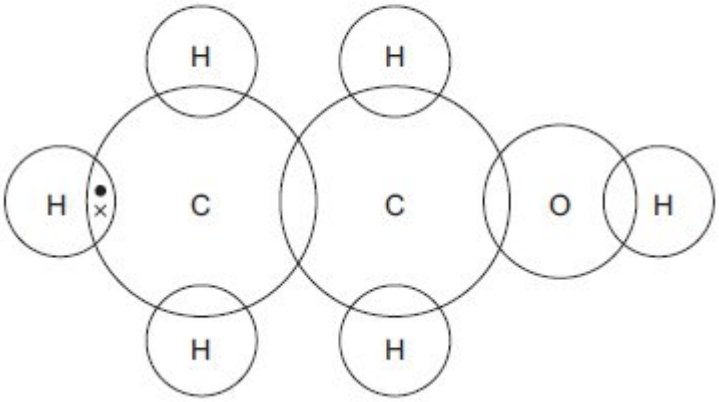
Figure 2



Complete the dot and cross diagram in **Figure 3** to show the bonding in ethanol.

Show the outer shell electrons only.

Figure 3

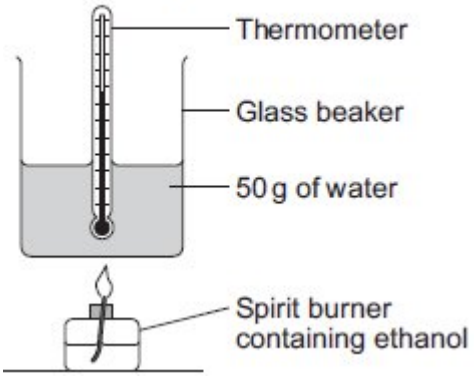


(2)

(c) A student burned some ethanol.

Figure 4 shows the apparatus the student used.

Figure 4



(i) The student recorded the temperature of the water before and after heating.

His results are shown in **Table 1**.

Table 1

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Temperature before heating	20.7 °C
Temperature after heating	35.1 °C

Calculate the energy used to heat the water.

Use the equation $Q = m \times c \times \Delta T$

The specific heat capacity of water = 4.2 J / g / °C

_____

_____

_____

_____

_____

Energy used = _____ J

(3)

(ii) **Table 2** shows the mass of the spirit burner before the ethanol was burned and after the ethanol was burned.

Table 2

Mass of spirit burner before ethanol was burned	72.80 g
Mass of spirit burner after ethanol was burned	72.10 g

Calculate the number of moles of ethanol (C_2H_5OH) that were burned.

Relative atomic masses (A_r): H = 1; C = 12; O = 16

_____

_____

_____

_____

_____

Number of moles burned = _____

(3)

(iii) Calculate the energy released in joules per mole.

You should assume that all the energy from the ethanol burning was used to heat the water.

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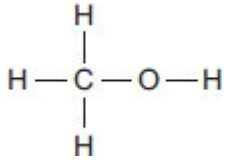
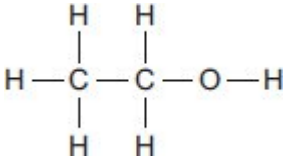
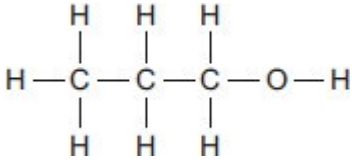
_____

Energy = _____ J / mole

(1)

(d) The names, structures and boiling points of ethanol and two other alcohols are shown in **Table 3**.

Table 3

Name	**Methanol**	**Ethanol**	**Propanol**
Structure			
Boiling point in °C	65	78	97

Use your knowledge of structure and bonding to suggest why the boiling points increase as the number of carbon atoms increases.

_____

_____

_____

_____

_____

_____

_____

(3)

(Total 15 marks)

Q15.

Dilute nitric acid reacts with potassium hydroxide solution.

The equation for the reaction is:

$$HNO_3 + KOH \longrightarrow KNO_3 + H_2O$$

A student investigated the temperature change in this reaction.

This is the method the student used.

Step 1 Put 25 cm^3 of dilute nitric acid in a polystyrene cup.
Step 2 Use a thermometer to measure the temperature of the dilute nitric acid.
Step 3 Use a burette to add 4 cm^3 of potassium hydroxide solution to the dilute nitric acid and stir the mixture.
Step 4 Use a thermometer to measure the highest temperature of the mixture.

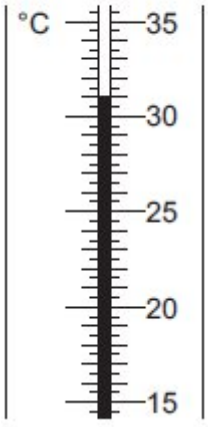
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Step 5 Repeat steps 3 and 4 until 40 cm^3 of potassium hydroxide solution have been added.

The dilute nitric acid and the potassium hydroxide solution were both at room temperature.

(a) **Figure 1** shows part of the thermometer after some potassium hydroxide solution had been added to the dilute nitric acid.

Figure 1



What is the temperature shown on the thermometer?

The temperature shown is _____ °C

(1)

(b) Errors are possible in this experiment.

(i) Suggest **two** causes of random error in the experiment.

_____

_____

_____

_____

(2)

(ii) Another student used a glass beaker instead of a polystyrene cup.

This caused a systematic error.

Why does using a glass beaker instead of a polystyrene cup cause a systematic error?

_____

_____

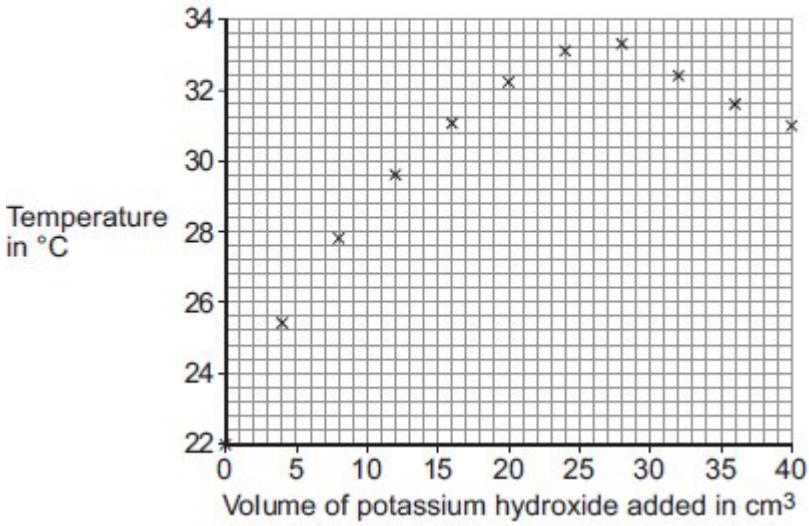
_____

(1)

(c) The results of the student using the polystyrene cup are shown in **Figure 2**.

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Figure 2



(i) How do the results in **Figure 2** show that the reaction between dilute nitric acid and potassium hydroxide solution is exothermic?

_____

_____

(1)

(ii) Explain why the temperature readings decrease between 28 cm^3 and 40 cm^3 of potassium hydroxide solution added.

_____

_____

_____

(2)

(iii) It is difficult to use the data in **Figure 2** to find the exact volume of potassium hydroxide solution that would give the maximum temperature.

Suggest further experimental work that the student should do to make it easier to find the exact volume of potassium hydroxide solution that would give the maximum temperature.

_____

_____

_____

_____

(2)

(d) The student did further experimental work and found that 31.0 cm^3 of potassium hydroxide solution neutralised 25.0 cm^3 of dilute nitric acid.

The concentration of the dilute nitric acid was 2.0 moles per dm^3.

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$$HNO_3 + KOH \longrightarrow KNO_3 + H_2O$$

Calculate the concentration of the potassium hydroxide solution in moles per dm^3.

_____

_____

_____

_____

_____

_____

Concentration = _____ moles per dm^3

(3)

(e) The student repeated the original experiment using 25 cm^3 of dilute nitric acid in a polystyrene cup and potassium hydroxide solution that was twice the original concentration.

She found that:

- a smaller volume of potassium hydroxide solution was required to reach the maximum temperature
- the maximum temperature recorded was higher.

Explain why the maximum temperature recorded was higher.

_____

_____

_____

_____

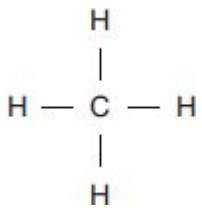
(2)

(Total 14 marks)

Q16.

Methane (CH_4) is used as a fuel.

(a) The displayed structure of methane is:



Draw a ring around a part of the displayed structure that represents a covalent bond.

(1)

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(b) Why is methane a compound?

Tick (✓) **one** box.

Methane contains atoms of two elements, combined chemically. ☐

Methane is not in the periodic table. ☐

Methane is a mixture of two different elements. ☐

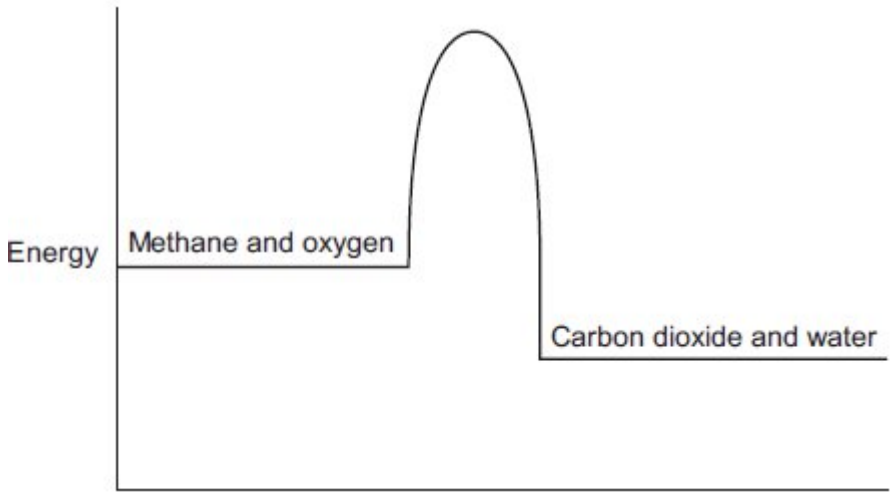
(1)

(c) Methane burns in oxygen.

(i) The diagram below shows the energy level diagram for the complete combustion of methane.

Draw and label arrows on the diagram to show:

- the activation energy
- the enthalpy change, ΔH.



(2)

(ii) Complete and balance the symbol equation for the complete combustion of methane.

$$CH_4 + _____ \longrightarrow CO_2 + _____$$

(2)

(iii) Explain why the **incomplete** combustion of methane is dangerous.

_____

_____

_____

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_____

(2)

(iv) Explain why, in terms of the energy involved in bond breaking and bond making, the combustion of methane is exothermic.

_____

_____

_____

_____

_____

_____

(3)

(d) Methane reacts with chlorine in the presence of sunlight.

The equation for this reaction is:



Some bond dissociation energies are given in the table.

Bond	**Bond dissociation energy in kJ per mole**
C−H	413
C−Cl	327
Cl−Cl	243
H−Cl	432

(i) Show that the enthalpy change, ΔH, for this reaction is −103 kJ per mole.

_____

_____

_____

_____

_____

_____

(3)

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(ii) Methane also reacts with bromine in the presence of sunlight.



This reaction is less exothermic than the reaction between methane and chlorine.

The enthalpy change, ΔH, is −45 kJ per mole.

What is a possible reason for this?

Tick (✓) **one** box.

CH_3Br has a lower boiling point than CH_3Cl ☐

The C−Br bond is weaker than the C−Cl bond. ☐

The H−Cl bond is weaker than the H−Br bond. ☐

Chlorine is more reactive than bromine. ☐

(1)

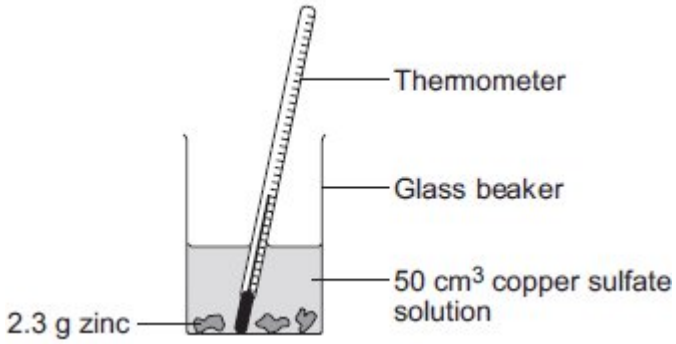
(Total 15 marks)

Q17.

A student investigated the temperature change when zinc reacts with copper sulfate solution.

The student used a different concentration of copper sulfate solution for each experiment.

The student used the apparatus shown below.



The student:

- measured 50 cm^3 copper sulfate solution into a glass beaker

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- measured the temperature of the copper sulfate solution
- added 2.3 g zinc
- measured the highest temperature
- repeated the experiment using copper sulfate solution with different concentrations.

The equation for the reaction is:

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

zinc + copper sulfate solution ⟶ copper + zinc sulfate solution

(a) The thermometer reading changes during the reaction.

Give **one** other change the student could **see** during the reaction.

_____

_____

(1)

(b) Suggest **one** improvement the student could make to the apparatus.

Give a reason why this improves the investigation.

Improvement _____

_____

Reason _____

_____

(2)

(c) **In this question you will be assessed on using good English, organising information clearly and using specialist terms where appropriate.**

The student's results are shown in the table below.

Experiment number	**Concentration of copper sulfate in moles per dm^3**	**Increase in temperature in °C**
1	0.1	5
2	0.2	10
3	0.3	12
4	0.4	20
5	0.5	25
6	0.6	30
7	0.7	35

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8	0.8	35
9	0.9	35
10	1.0	35

Describe **and** explain the trends shown in the student's results.

_____

_____

_____

_____

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_____

_____

_____

_____

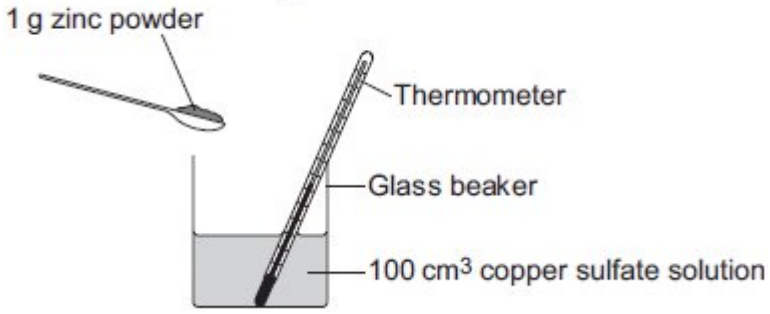
(6)

(Total 9 marks)

Q18.

A student investigates the energy released when zinc powder reacts with copper sulfate solution. The student uses the apparatus shown in **Figure 1**.

Figure 1



The student:

- measures 100 cm^3 copper sulfate solution into a beaker
- measures the temperature of the copper sulfate solution
- puts 1 g zinc powder into the beaker
- stirs the mixture with a thermometer
- measures the highest temperature.

The student's results were:

Starting temperature = 21 °C

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Highest temperature = 32 °C

(a) (i) Calculate the change in temperature.

_____

Change in temperature = _____ °C

(1)

(ii) Calculate the energy released in the reaction.

Use the equation

energy released in J = volume of solution in cm^3 × 4.2 × temperature change in °C

_____

_____

Energy released = _____ J

(2)

(b) The reaction of zinc with copper sulfate is exothermic.

How can you tell from the student's results that the reaction is exothermic?

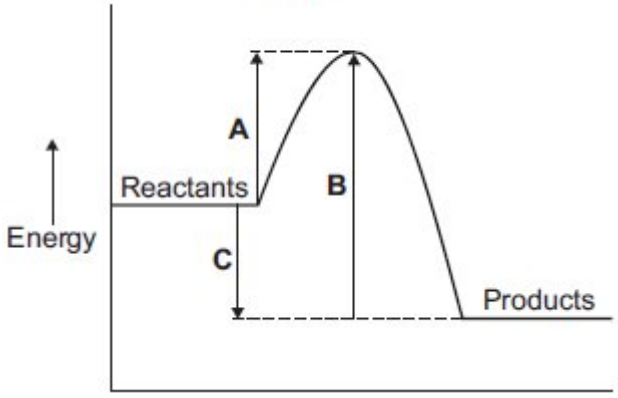
_____

_____

(1)

(c) The energy diagram for the reaction is shown in **Figure 2**.

Figure 2



(i) How can you tell from the energy diagram that the reaction is exothermic?

_____

_____

(1)

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(ii) Which arrow shows the activation energy in **Figure 2**?

Tick (✓) **one** box.

A ☐

B ☐

C ☐

(1)

(Total 6 marks)

Q19.

This question is about reversible reactions and chemical equilibrium.

(a) Reversible reactions can reach equilibrium in a closed system.

(i) What is meant by a closed system?

_____

_____

(1)

(ii) Explain why, when a reversible reaction reaches equilibrium, the reaction appears to have stopped.

_____

_____

_____

_____

(2)

(b) In the Haber process, the reaction of nitrogen with hydrogen to produce ammonia is reversible.

$$N_2(g) + 3\,H_2(g) \rightleftharpoons 2\,NH_3(g)$$

(i) Name a natural resource from which hydrogen is produced.

_____

(1)

(ii) The Haber process uses a catalyst to speed up the reaction.

Explain how a catalyst speeds up a reaction.

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_____

_____

_____

_____

(2)

(iii) What happens to the amount of ammonia produced at equilibrium if the pressure is increased?

Give a reason for your answer.

_____

_____

_____

_____

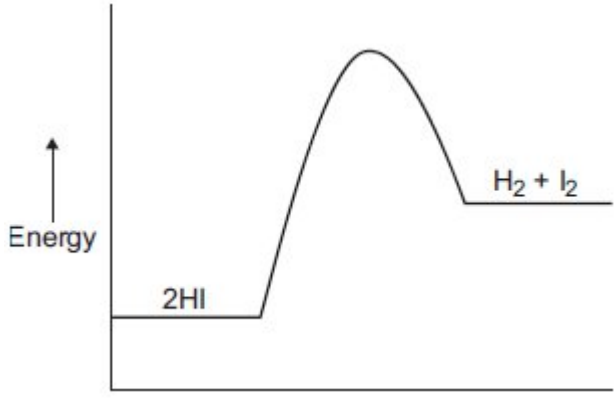
(2)

(c) The decomposition of hydrogen iodide into hydrogen and iodine is reversible.

$$2HI(g) \rightleftharpoons H_2(g) + I_2(g)$$

The forward reaction is endothermic.

The energy level diagram shown below is for the forward reaction.



(i) Draw an arrow to show the activation energy on the diagram.

(1)

(ii) How does the diagram show that the reaction is endothermic?

_____

_____

(1)

(iii) Suggest what effect, if any, increasing the temperature will have on the amount of hydrogen iodide at equilibrium.

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Give a reason for your answer.

_____

_____

_____

_____

(2)

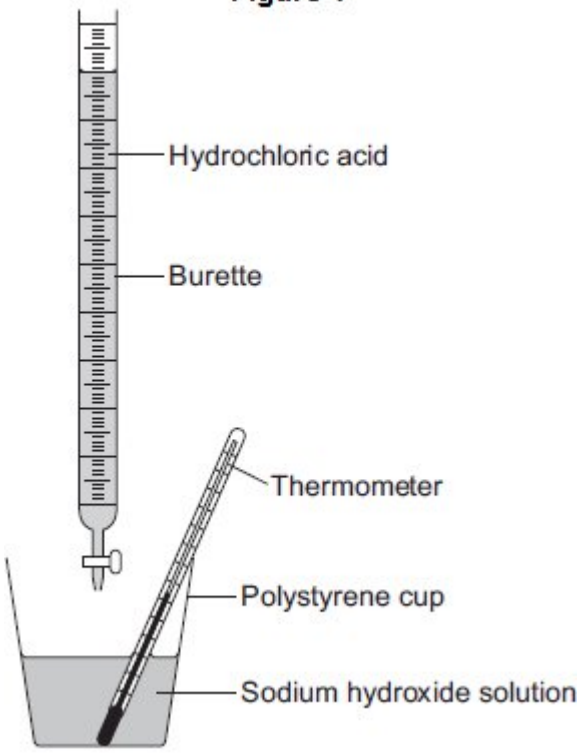
(Total 12 marks)

Q20.

A student investigates the energy released when hydrochloric acid completely neutralises sodium hydroxide solution.

The student uses the apparatus shown in **Figure 1**.

Figure 1



The student:

- measures 25 cm^3 sodium hydroxide solution into a polystyrene cup
- fills a burette with hydrochloric acid
- measures the temperature of the sodium hydroxide solution
- adds 5 cm^3 hydrochloric acid to the sodium hydroxide solution in the polystyrene cup
- stirs the mixture and measures the highest temperature of the mixture
- continues to add 5 cm^3 portions of hydrochloric acid, stirring and measuring the highest temperature of the mixture after each addition.

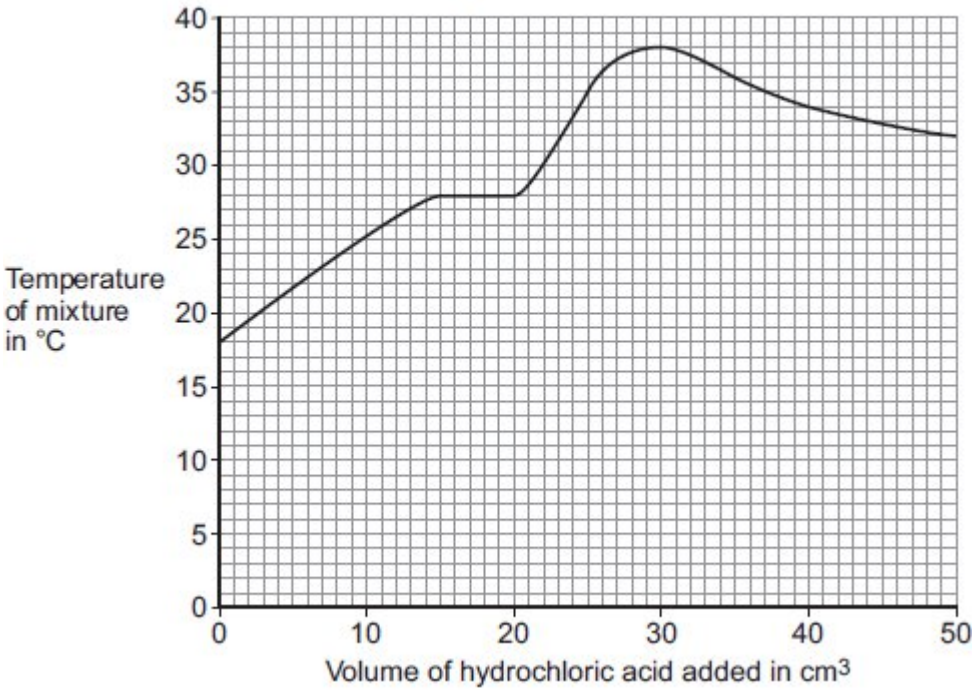
(a) The student has plotted a graph of the results.

The graph line has been incorrectly drawn by including an anomalous result.

The graph is shown in **Figure 2**.

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Figure 2



(i) Suggest a cause for the anomalous result when 20 cm^3 of hydrochloric acid is added.

_____

_____

(1)

(ii) Suggest the true value of the temperature of the anomalous point.

Temperature* = _____ *°C

(1)

(iii) What was the **total** volume of the mixture when the maximum temperature was reached?

_____

Total volume of the mixture* = _____ *cm^3

(1)

(iv) Calculate the overall temperature increase in this experiment.

_____

Overall temperature increase* = _____ *°C

(1)

(v) Use your answers to (iii) and (iv) and the equation to calculate the energy released in the reaction. Give the unit.

Assume the volume in cm^3 is equivalent to the mass of solution in grams.

Equation: $Q = mc\Delta T$

where:
Q = energy released

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m = mass of solution (g)
c = 4.2 (J per g per °C)
ΔT = change in temperature (°C)

_____

_____

Energy released = _____ Unit = _____

(2)

(b) The student did the experiment again, starting with 50 cm^3 of sodium hydroxide solution instead of 25 cm^3.

Explain why this would make no difference to the overall temperature increase.

_____

_____

_____

_____

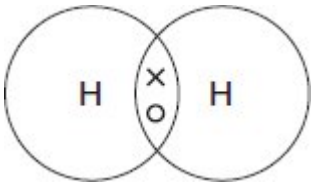
(2)

(Total 8 marks)

Q21.

Hydrogen gas is produced by the reaction of methane and steam.

(a) The diagram represents a molecule of hydrogen.



(i) What type of bond joins the atoms of hydrogen?

Tick (✔) **one** box.

Covalent ☐

Metallic ☐

Ionic ☐

(1)

(ii) A catalyst is used in the reaction.

Draw a ring around the correct answer to complete the sentence.

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A catalyst

increases the rate of reaction.
increases the temperature.
increases the yield of a reaction.

(1)

(b) The equation for the reaction of methane and steam is:

$$CH_4(g) + H_2O(g) \rightleftharpoons CO(g) + 3H_2(g)$$

(i) What is meant by the symbol $\rightleftharpoons$?

_____

(1)

(ii) Lowering the pressure reduces the rate of reaction.

Explain why, in terms of particles.

_____

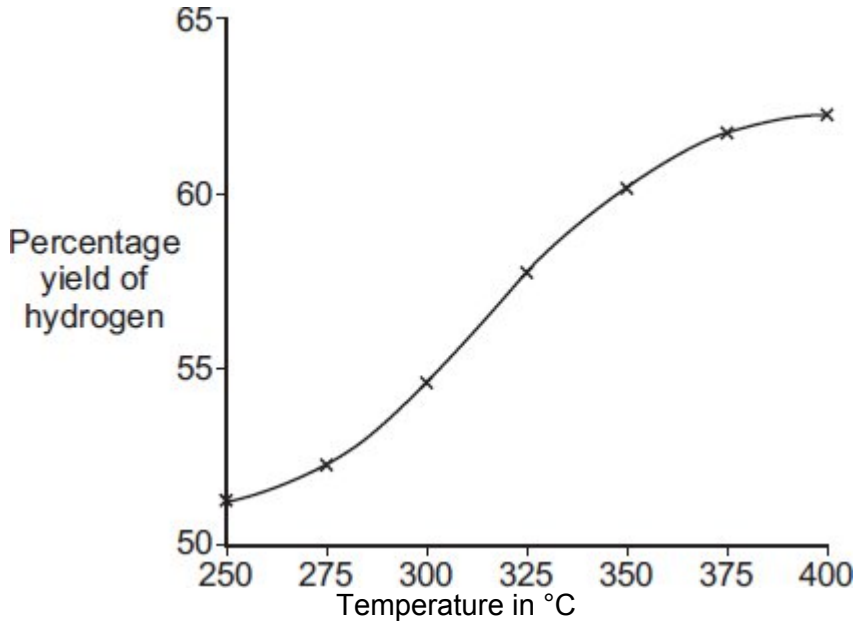
_____

_____

_____

(2)

(iii) The graph shows the yield of hydrogen at different temperatures.



The forward reaction is endothermic.

How does the graph show that the forward reaction is endothermic?

_____

_____

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(1)

(iv) Why is a higher yield produced if the reaction is repeated at a lower pressure?

_____

_____

(1)

(c) *In this question you will be assessed on using good English, organising information clearly and using specialist terms where appropriate.*

Car engines are being developed that use hydrogen gas as a fuel instead of petrol.

The table compares the two fuels.

	Hydrogen	**Petrol**
Energy	5700 kJ per litre	34 000 kJ per litre
State	Gas	Liquid
Equation for combustion	$2H_2 + O_2 \rightarrow 2H_2O$	$2C_8H_{18} + 25O_2 \rightarrow 16CO_2 + 18H_2O$
How the fuel is obtained	Most hydrogen is produced from coal, oil or natural gas. Hydrogen can be produced by the electrolysis of water or the solar decomposition of water.	Fractional distillation of crude oil.

Use the information in the table and your knowledge of fuels to evaluate the use of hydrogen instead of petrol as a fuel.

You should describe the advantages and disadvantages of using hydrogen instead of petrol.

_____

_____

_____

_____

_____

_____

_____

_____

_____

_____

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Extra space _____

_____

_____

_____

_____

_____

(6)

(Total 13 marks)

Q22.

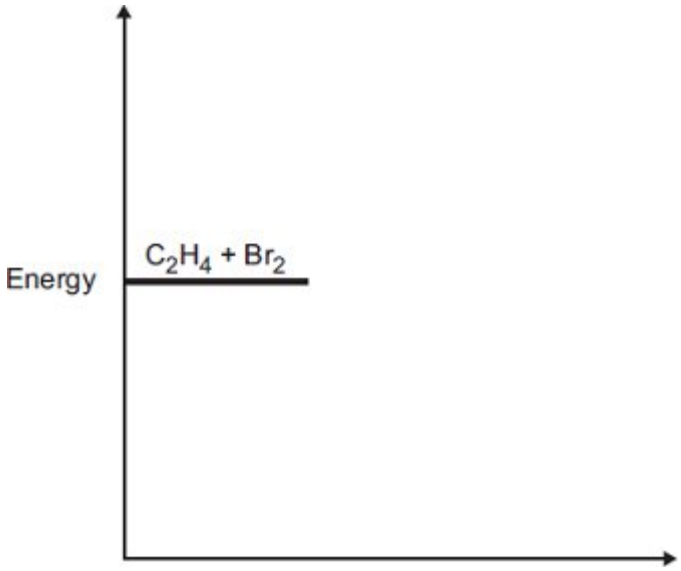
The equation for the reaction of ethene and bromine is:

$$C_2H_4(g) + Br_2(l) \longrightarrow C_2H_4Br_2(l)$$

The reaction is exothermic.

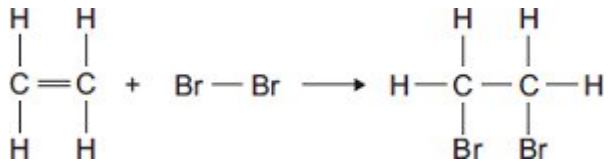
(a) Complete the energy level diagram.

You should label:
- the activation energy
- the enthalpy change (ΔH).



(3)

(b) (i) The equation for the reaction can be represented as:



Bond	Bond dissociation energy in kJ per mole

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C—H	413
C = C	614
Br—Br	193
C—C	348
C—Br	276

Use the bond dissociation energies in the table to calculate the enthalpy change (ΔH) for this reaction.

_____

_____

_____

_____

_____

_____

Enthalpy change (ΔH) = _____ kJ per mole

(3)

(ii) The reaction is exothermic.

Explain why, in terms of bonds broken and bonds formed.

_____

_____

_____

_____

_____

(2)

(Total 8 marks)

Q23.

A company manufactures ethanol (C_2H_5OH).

The reaction for the process is:

$$C_2H_4(g) + H_2O(g) \rightleftharpoons C_2H_5OH(g) \qquad \Delta H = -45 \text{ kJ per mole}$$

The temperature and pressure can be changed to increase the yield of ethanol at equilibrium.

(a) Explain what is meant by equilibrium.

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_____

_____

_____

_____

_____

_____

(3)

(b) (i) How would increasing the temperature change the **yield** of ethanol at equilibrium?

Give a reason for your answer.

_____

_____

_____

_____

_____

(2)

(ii) How would increasing the pressure change the **yield** of ethanol at equilibrium?

Give a reason for your answer.

_____

_____

_____

_____

_____

(2)

(c) A catalyst is added to increase the rate of the reaction.

Explain how adding a catalyst increases the rate of a chemical reaction.

_____

_____

_____

_____

(2)

(Total 9 marks)

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Q24.

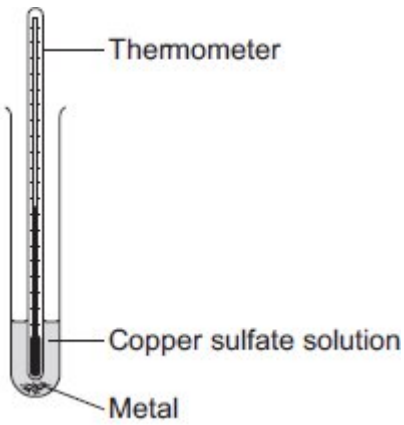
A student investigated displacement reactions of metals.

The student added different metals to copper sulfate solution and measured the temperature change.

The more reactive the metal is compared with copper, the bigger the temperature change.

The apparatus the student used is shown in **Figure 1**.

Figure 1



(a) State **three** variables that the student must control to make his investigation a fair test.

1. _____

2. _____

3. _____

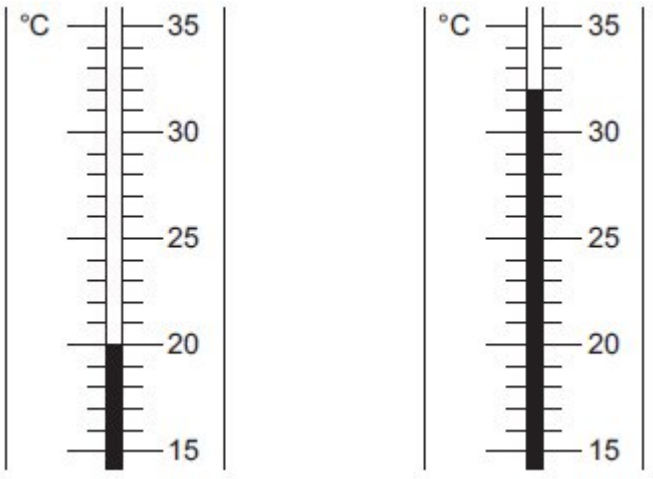
(3)

(b) **Figure 2** shows the thermometer in one experiment before and after the student added a metal to the copper sulfate solution.

Figure 2

Before adding metal **After adding metal**

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Use **Figure 2** to complete **Table 1**.

Table 1

Temperature before adding metal in °C	_____
Temperature after adding metal in °C	_____
Change in temperature in °C	_____

(3)

(c) The student repeated the experiment three times with each metal.

Table 2 shows the mean temperature change for each metal.

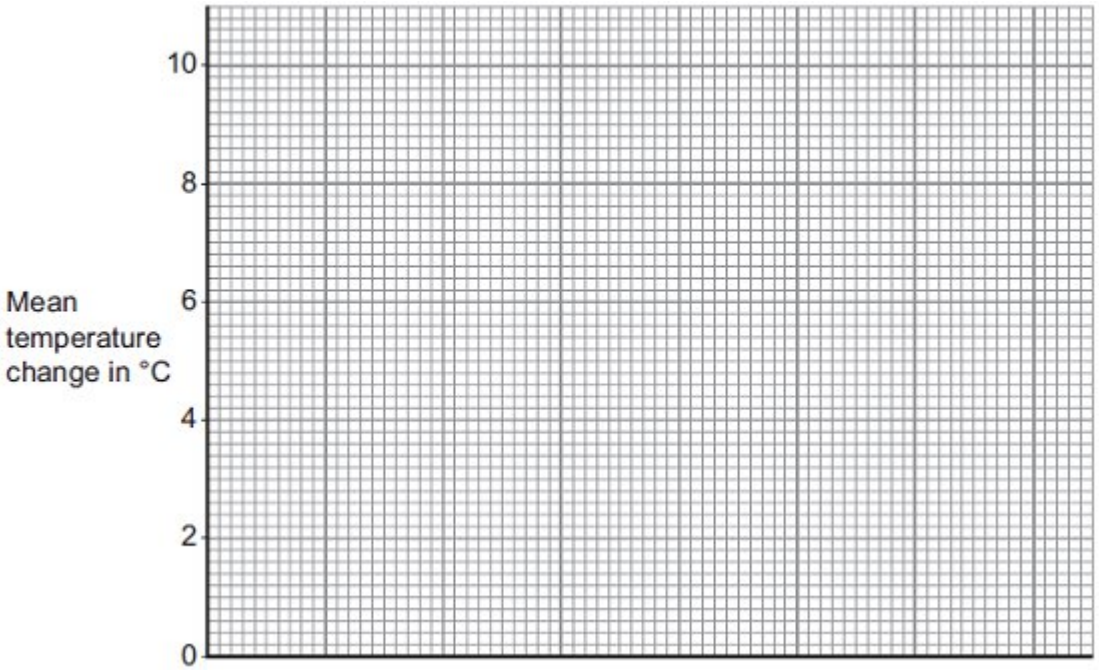
Table 2

Metal	**Mean temperature change in °C**
Cobalt	4.5
Gold	0.0
Magnesium	10.0
Nickel	3.0
Silver	0.0
Tin	1.5

(i) On **Figure 3**, draw a bar chart to show the results.

Figure 3

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(3)

(ii) Why is a line graph **not** a suitable way of showing the results?

_____

_____

(1)

(iii) Use the results to work out which metal is the most reactive.

Give a reason for your answer.

Most reactive metal _____

Reason _____

_____

(2)

(iv) Explain why there was no temperature change when silver metal was added to the copper sulfate solution.

_____

_____

_____

_____

(2)

(v) It is **not** possible to put all six metals in order of reactivity using these results.

Suggest how you could change the experiment to be able to put all six metals into order of reactivity.

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_____

_____

_____

_____

_____

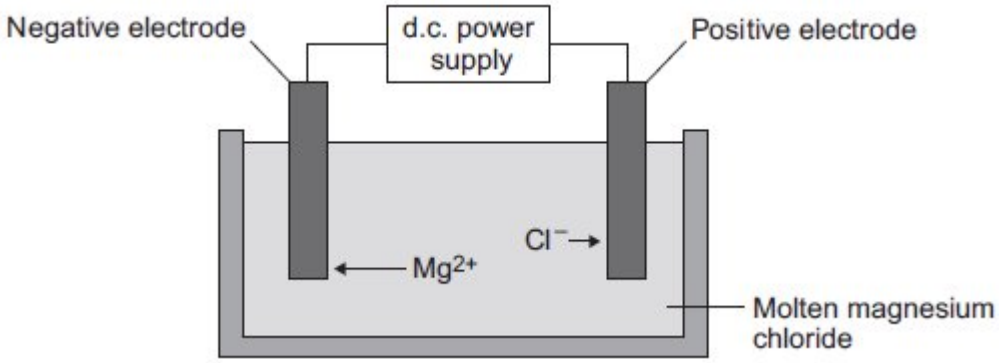
(2)

(Total 16 marks)

Q25.

Some students investigated reactions to produce magnesium.

(a) The students used electrolysis to produce magnesium from magnesium chloride, as shown in the figure below.



(i) Magnesium chloride contains magnesium ions and chloride ions.

Why does solid magnesium chloride **not** conduct electricity?

_____

_____

(1)

(ii) One of the products of the electrolysis of molten magnesium chloride is magnesium.

Name the other product.

_____

(1)

(iii) Why do magnesium ions (Mg^{2+}) move to the negative electrode?

_____

_____

(1)

(iv) At the negative electrode, the magnesium ions (Mg^{2+}) gain electrons to become magnesium atoms.

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How many electrons does each magnesium ion gain?

_____

(1)

(b) The students did the experiment four times and weighed the magnesium produced.

The table below shows their results.

Experiment	Mass of magnesium produced in grams
1	1.13
2	0.63
3	1.11
4	1.09

(i) There is an anomalous result.

Suggest **one** possible reason for the anomalous result.

_____

_____

(1)

(ii) Calculate the mean mass of magnesium produced, taking account of the anomalous result.

_____

_____

_____

Mean mass = _____ g

(2)

(c) The formula of magnesium chloride is $MgCl_2$

The relative formula mass of magnesium chloride is 95.

The relative atomic mass of magnesium is 24.

(i) Use the equation to calculate the percentage mass of magnesium in magnesium chloride.

$$\text{Percentage mass of magnesium} = \frac{\text{mass of magnesium}}{\text{mass of magnesium chloride}} \times 100\%$$

_____

_____

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Percentage mass of magnesium in magnesium chloride = _____ %

(2)

(ii) Draw a ring around the relative mass of chlorine in $MgCl_2$

71 **95** **119**

(1)

(d) Magnesium is also produced from the reaction of magnesium oxide with silicon.

(i) The equation for the reaction is:

$$2\ MgO(s) + Si(s) \rightleftharpoons SiO_2(s) + 2\ Mg(s)$$

What is the meaning of this symbol $\rightleftharpoons$?

Draw a ring around the correct answer.

neutralisation reaction **precipitation reaction** **reversible reaction**

(1)

(ii) The forward reaction is endothermic.

Draw a ring around the correct answer to complete the sentence.

In an endothermic reaction the temperature of the surroundings

decreases.
increases.
stays the same.

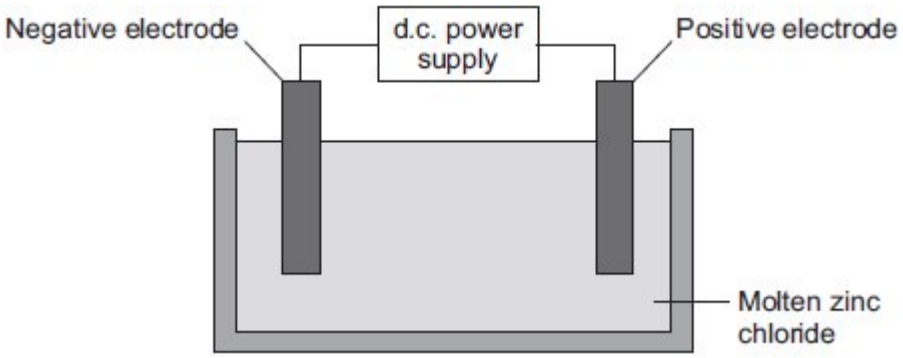
(1)

(Total 12 marks)

Q26.

This question is about zinc and magnesium.

Zinc is produced by electrolysis of molten zinc chloride, as shown in the figure below.



(a) (i) Why must the zinc chloride be molten for electrolysis?

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_____

_____

(1)

(ii) Describe what happens at the negative electrode.

_____

_____

_____

_____

_____

_____

(3)

(iii) Complete the half equation for the reaction at the positive electrode.

_____ ⟶ Cl_2 + _____ e^-

(1)

(b) Magnesium can be produced from magnesium oxide.

The equation for the reaction is:

$$Si(s) + 2\,MgO(s) \longrightarrow SiO_2(s) + 2\,Mg(g)$$

(i) How can you tell from the equation that the reaction is done at a high temperature?

_____

_____

(1)

(ii) This reaction to produce magnesium from magnesium oxide is **endothermic**.

What is meant by an **endothermic** reaction?

_____

_____

(1)

(iii) A company made magnesium using this reaction.

Calculate the mass of magnesium oxide needed to produce 1.2 tonnes of magnesium.

Relative atomic masses (A_r): O = 16; Mg = 24

_____

_____

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_____

_____

Mass of magnesium oxide needed = _____ tonnes

(3)

(iv) The company calculated that they would produce 1.2 tonnes of magnesium, but only 0.9 tonnes was produced.

Calculate the percentage yield.

_____

_____

Percentage yield = _____ %

(1)

(v) Give **one** reason why the calculated yield of magnesium might not be obtained.

_____

_____

(1)

(Total 12 marks)

Q27.

Some cars are powered by hydrogen fuel cells.

Figure 1



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(a) What type of energy is released by hydrogen fuel cells?

Draw a ring around the correct answer.

chemical **electrical** **light**

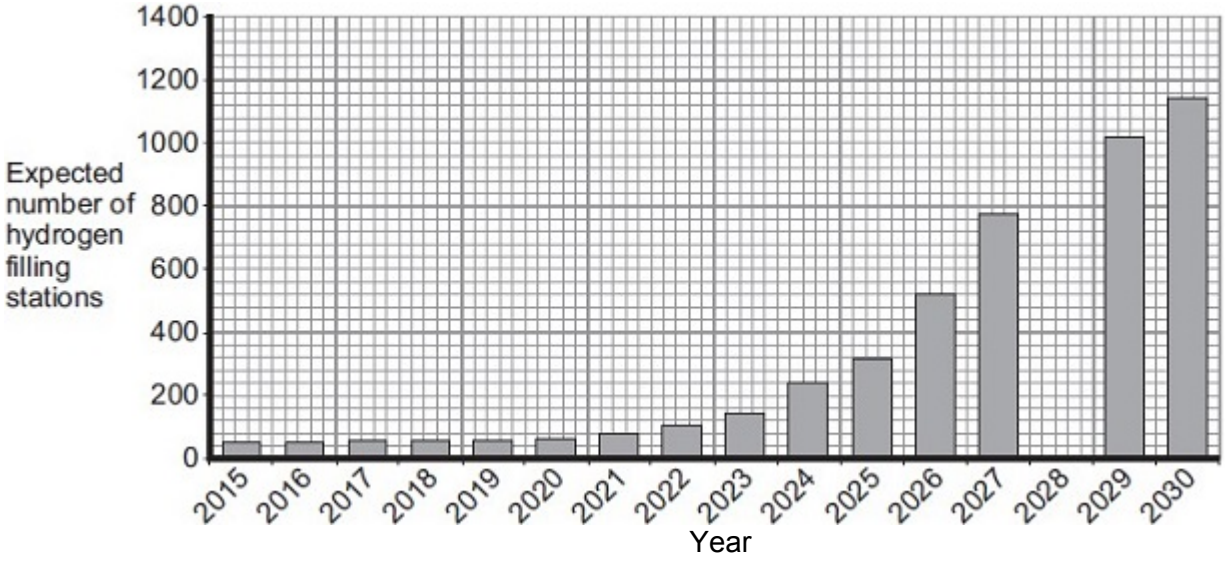
(1)

(b) Owners of cars powered by fuel cells buy hydrogen from hydrogen filling stations.

Figure 2 shows how the number of hydrogen filling stations in the UK is expected to increase up to the year 2030.

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Figure 2



(i) Suggest the total number of hydrogen filling stations expected in 2028.

_____

(1)

(ii) The number of hydrogen filling stations will still be very low compared with the number of petrol filling stations.

Suggest **one** reason why.

_____

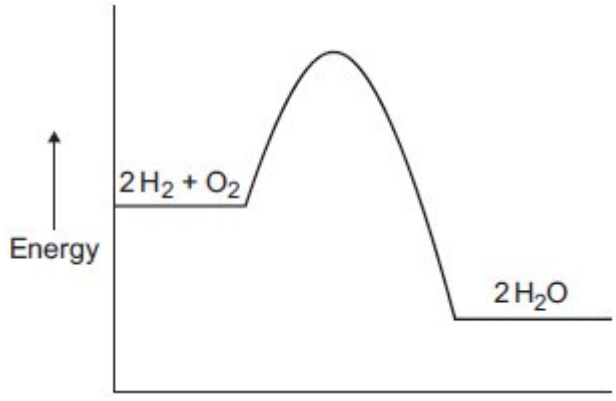
_____

(1)

(c) Hydrogen reacts with oxygen to produce water.

The energy level diagram for this reaction is shown in **Figure 3**.

Figure 3



Mark clearly with a cross (**x**) on **Figure 3** where bond breaking happens.

(1)

(Total 4 marks)

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Q28.

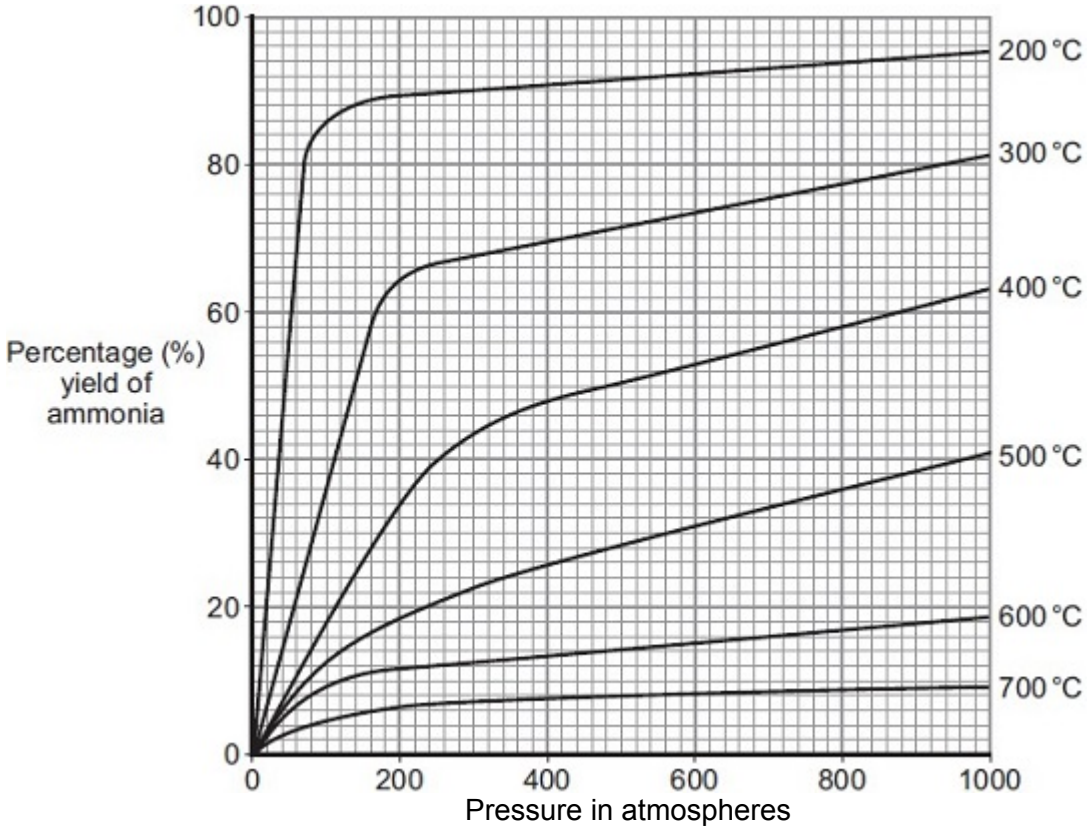
In 1909 Fritz Haber invented a process to produce ammonia from nitrogen and hydrogen.

(a) Complete and balance the chemical equation for the production of ammonia from nitrogen and hydrogen.

$$N_2 \quad + \quad 3\ H_2 \quad \rightleftharpoons \quad _____$$

(2)

(b) The figure below shows how the equilibrium yield of ammonia changes with pressure at different temperatures.



(i) Use the information in given in the figure to complete the sentence.

The temperature on the graph that gives the highest yield of ammonia is

_____ °C.

(1)

(ii) The temperature used in the Haber process for the production of ammonia is 450 °C.

Why is a temperature much lower than 450 °C **not** used for the Haber process?

_____

_____

(1)

(iii) Use the information in the figure to answer this question.

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Draw a ring around the pressure that gives the highest yield of ammonia.

100 **200** **300** **400**

(1)

(iv) The pressure used in the Haber process for the production of ammonia is 200 atmospheres.

Why is a pressure lower than 200 atmospheres **not** used for the Haber process?

_____

_____

(1)

(c) Explain how ammonia is separated from unreacted nitrogen and hydrogen in the Haber process.

_____

_____

_____

_____

(2)

(Total 8 marks)

Q29.

Some cars are powered by hydrogen fuel cells.

Figure 1



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(a) What type of energy is released by hydrogen fuel cells?

_____

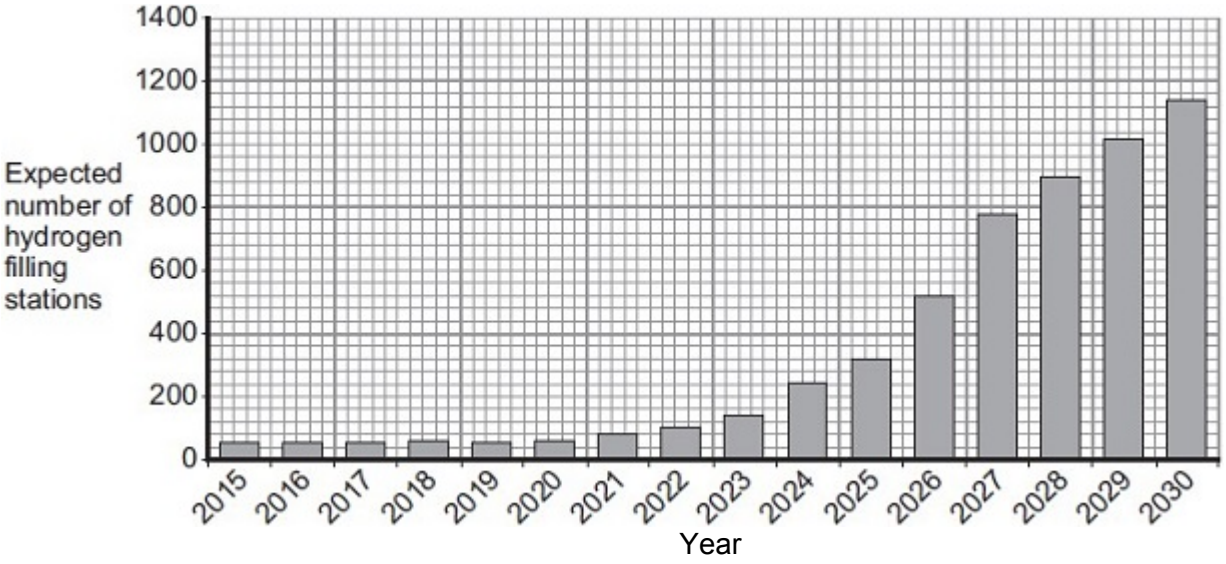
(1)

(b) Owners of cars powered by fuel cells buy hydrogen from hydrogen filling stations.

Figure 2 shows how the number of hydrogen filling stations in the UK is expected to increase up to the year 2030.

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Figure 2



Use the information in **Figure 2** and your own knowledge to answer this question.

Suggest **two** reasons why the UK government might encourage the building of more hydrogen filling stations.

_____

_____

_____

_____

_____

(2)

(c) The equation for the reaction of hydrogen with oxygen is:

$$2\ H_2 \quad + \quad O_2 \longrightarrow \quad 2\ H_2O$$

During the reaction, energy is used to break the bonds of the reactants.

Energy is released when new bonds are made to form the product.

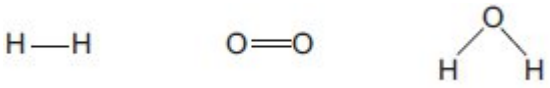
Bond energies for the reaction are given in the table below.

Bond	Bond energy in kJ
H—H	436
O=O	498
O—H	464

The structures of the reactants and product are shown in **Figure 3**.

Figure 3

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hydrogen oxygen water

(i) Calculate the energy change for the reaction:

$$2\ H_2 + O_2 \longrightarrow 2\ H_2O$$

Energy change = _____ kJ

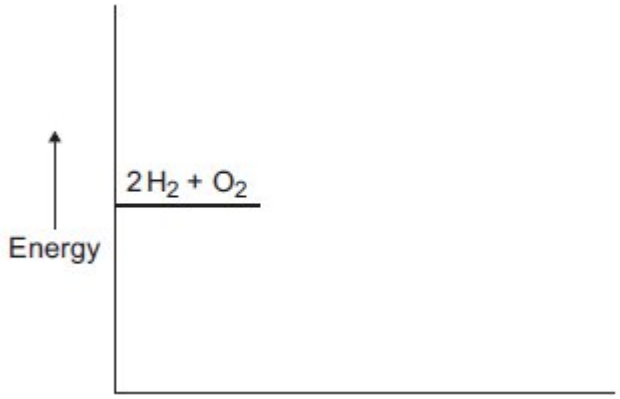
(3)

(ii) The reaction of hydrogen with oxygen is exothermic.

Complete the energy level diagram for this reaction on **Figure 4**.

Clearly label the activation energy.

Figure 4



(3)

(Total 9 marks)

Q30.

Kelp is a seaweed.

Kelp can be burned to give out energy.

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© Ethan Daniels/Shutterstock

(a) Draw a ring around the correct answer to complete each sentence.

Reactions which give out energy are

endothermic.

exothermic.

reversible.

(1)

(b) Which **two** of the following questions **cannot** be answered by scientific experiments alone?

Tick (✓) **two** boxes.

Question	Tick (✓)
How much carbon dioxide is produced when 100 g of kelp is burned?	
Does kelp give out more heat energy than coal when burned?	
Should people use kelp instead of oil as an energy source?	
Will kelp be more popular than coal in the next 10 years?	

(2)

(c) Potassium iodide can be produced from kelp.

(i) Potassium can be reacted with iodine to produce potassium iodide.

potassium + iodine → potassium iodide

The diagram shows how this happens.

Only the outer electrons are shown.

The dots (●) and crosses (×) are used to represent electrons

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Use the diagram to help you answer this question.

Describe, as fully as you can, what happens when potassium reacts with iodine to produce potassium iodide.

To get full marks you should use the words atom, electron and ion in your answer.

_____

_____

_____

_____

_____

_____

_____

_____

_____

_____

(4)

(ii) Potassium iodide reacts with lead nitrate.

$$2\ KI(aq) + Pb(NO_3)_2(aq) \rightarrow 2\ KNO_3(aq) + PbI_2(s)$$

Why is this reaction a precipitation?

_____

_____

(1)

(iii) How can the precipitate be removed from the reaction mixture?

_____

_____

(1)

(Total 9 marks)

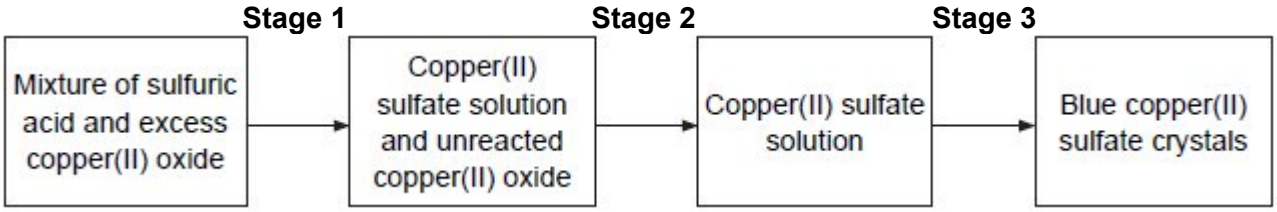
Q31.

This question is about compounds of copper.

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(a) A student made some copper(II) sulfate crystals.

The flow diagram shows the stages of the preparation of copper(II) sulfate crystals.



(i) The reaction mixture is heated in **Stage 1**.

Suggest why.

_____

_____

(1)

(ii) Complete the equation for this reaction.

CuO + _____ → $CuSO_4$ + _____

(2)

(iii) How would the student remove the unreacted copper(II) oxide in **Stage 2**?

_____

_____

(1)

(iv) How would the student obtain copper(II) sulfate crystals from the copper(II) sulfate solution in **Stage 3**?

_____

(1)

(v) The mass of crystals obtained was less than the student had calculated.

Suggest **one** reason why.

_____

_____

(1)

(b) The student heated the blue copper(II) sulfate crystals.

The word equation for the reaction is shown below.

hydrated copper(II) sulfate ⇌ anhydrous copper(II) sulfate + water

blue white

(i) What does the symbol ⇌ mean ?

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_____

(1)

(ii) 300 J of energy are taken in when some blue copper(II) sulfate crystals are heated.

What is the energy change when an excess of water is added to the anhydrous copper(II) sulfate produced?

_____

_____

(2)

(c) A sample of copper nitride contains 3.81 g of copper and 0.28 g of nitrogen.

Calculate the empirical formula.

You **must** show all your working to get full marks.

Relative atomic masses (A_r): N = 14; Cu = 63.5.

_____

_____

_____

_____

_____

_____

_____

Empirical formula = _____

(4)

(Total 13 marks)

Q32.

Kelp is a seaweed.

Kelp can be used in foods and as a renewable energy source.

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(a) Scientific experiments, on their own, **cannot** fully answer one of the following questions. Which one?

Tick (✓) **one** box.

Questions	Tick (✓)
How much carbon dioxide is produced when 100 g of kelp is burned?	
Does kelp give out more heat energy than coal?	
Will kelp last longer than coal as an energy source?	
Which fuel, kelp or coal, produces the most ash when burned?	

(1)

(b) Scientists cannot answer the question 'should people use kelp instead of coal as an energy source?'

Give **two** reasons why.

_____

_____

_____

_____

(2)

(c) Sodium iodide can be produced from kelp.

(i) How many electrons are in the outer shell of an iodine atom?

(1)

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(ii) Sodium iodide contains sodium ions (Na^+) and iodide ions (I^-).

Describe, as fully as you can, what happens when sodium atoms react with iodine atoms to produce sodium iodide.

You may use a diagram in your answer

_____

_____

_____

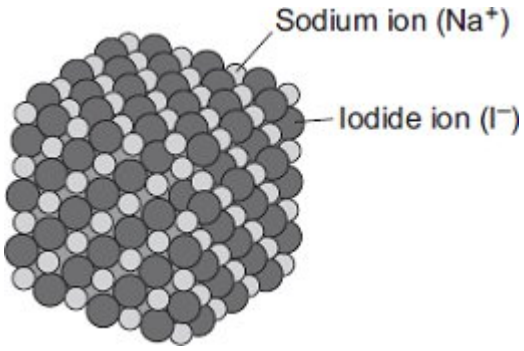
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_____

_____

(3)

(iii) The diagram shows the structure of sodium iodide.



Solid sodium iodide does not conduct electricity.

Why does sodium iodide solution conduct electricity?

_____

_____

(1)

(iv) When sodium iodide solution is electrolysed, iodine is formed at the positive electrode.

Complete and balance the half equation for the formation of iodine.

$$_____I^- \rightarrow I_2 + _____e^-$$

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(1)

(v) What is formed at the negative electrode when sodium iodide solution is electrolysed?

Explain why.

_____

_____

_____

_____

(2)

(Total 11 marks)

Q33.

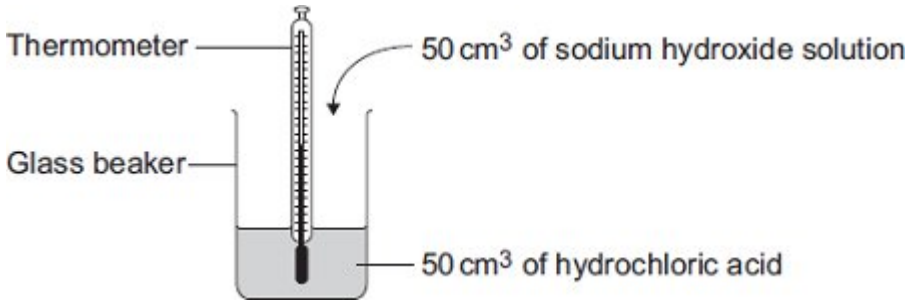
Read the information about energy changes and then answer the questions.

A student did an experiment to find the energy change when hydrochloric acid reacts with sodium hydroxide.

The equation which represents the reaction is:

$$HCl + NaOH \rightarrow NaCl + H_2O$$

The student used the apparatus shown in the diagram.



The student placed 50 cm^3 of hydrochloric acid in a glass beaker and measured the initial temperature.

The student then quickly added 50 cm^3 of sodium hydroxide solution and stirred the mixture with the thermometer. The highest temperature was recorded.

The student repeated the experiment, and calculated the temperature change each time.

	Experiment 1	**Experiment 2**	**Experiment 3**	**Experiment 4**
Initial temperature in °C	19.0	22.0	19.2	19.0
Highest temperature in °C	26.2	29.0	26.0	23.5
Temperature	7.2	7.0	6.8	4.5

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change in °C				

(a) The biggest error in this experiment is heat loss.

Suggest how the apparatus could be modified to reduce heat loss.

_____

_____

(1)

(b) Suggest why it is important to mix the chemicals thoroughly.

_____

(1)

(c) Which **one** of these experiments was probably done on a different day to the others?

Give a reason for your answer.

_____

(1)

(d) Suggest why experiment **4** should **not** be used to calculate the average temperature change.

_____

_____

(1)

(e) Calculate the average temperature change from the first three experiments.

_____

Answer = _____ °C

(1)

(f) Use the following equation to calculate the energy change for this reaction.

Energy change in joules = 100 × 4.2 × average temperature change

_____

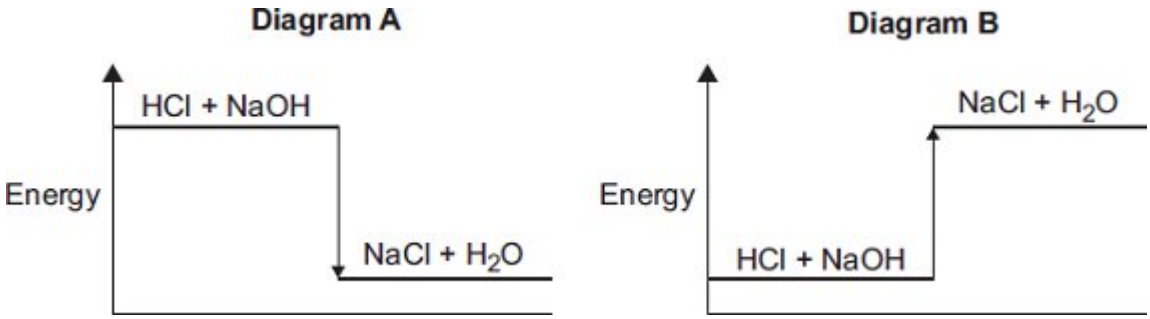
Answer = _____ J

(1)

(g) Which **one** of these energy level diagrams represents the energy change for this reaction?

Give a reason for your answer.

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_____

_____

(1)

(Total 7 marks)

Q34.

The following steps show how to use a type of glue.

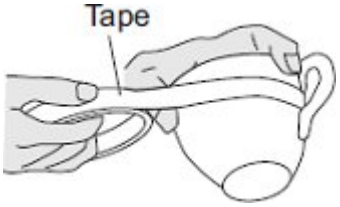
Step 1 Measure out equal amounts of the liquids from tubes **A** and **B**.



Step 2 Mix the liquids to make the glue.
Put a thin layer of the glue onto each of the surfaces to be joined.



Step 3 Put the pieces together and hold them with tape.



Step 4 Leave the glue to set.

(a) When liquids **A** and **B** are mixed a chemical reaction takes place.

This reaction is *exothermic*.

What does *exothermic* mean?

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_____

_____

_____

_____

(2)

(b) The time taken for the glue to set at different temperatures is given in the table below.

Temperature in°C	Time taken for the glue to set
20	3 days
60	6 hours
90	1 hour

(i) Use the correct answer from the box to complete each sentence.

decreases	**increases**	**stays the same**

When the temperature is increased the time taken for the glue to set

_____

When the temperature is increased the rate of the setting reaction

_____

(2)

(ii) Tick (✓) **two** reasons why an increase in temperature affects the rate of reaction.

Reason	Tick (✓)
It gives the particles more energy	
It increases the concentration of the particles	
It increases the surface area of the particles	
It makes the particles move faster	

(2)

(Total 6 marks)

Q35.

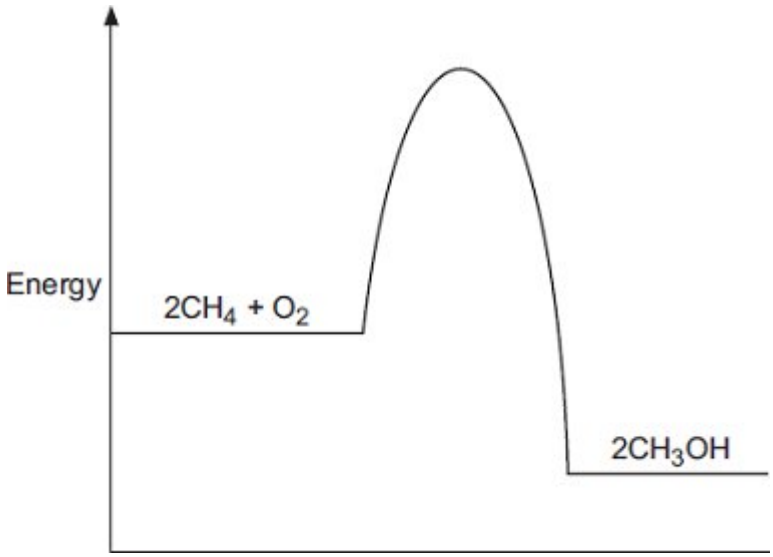
Methanol (CH_3OH) can be made by reacting methane (CH_4) and oxygen (O_2).
The reaction is exothermic.

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The equation for the reaction is:

$$2CH_4 + O_2 \longrightarrow 2CH_3OH$$

(a) The energy level diagram for this reaction is given below.



(i) How does the diagram show that this reaction is exothermic?

_____

_____

_____

(1)

(ii) A platinum catalyst can be used to increase the rate of this reaction.

What effect does adding a catalyst have on the energy level diagram?

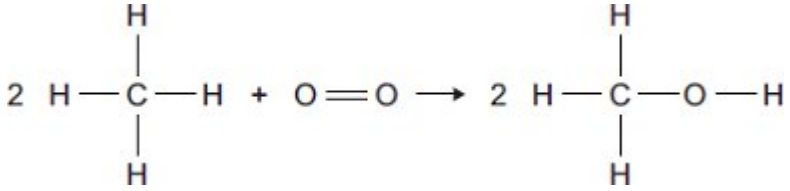
_____

_____

_____

(1)

(b) The equation can also be written showing the structural formulae of the reactants and the product.



(i) Use the bond energies given in the table to help you to calculate the energy change for this reaction.

Bond	Bond energy in kJ

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C — H	435
O ═ O	497
C — O	336
O — H	464

_____

_____

_____

_____

Energy change = _____ kJ

(3)

(iii) In terms of the bond energies, why is this an exothermic reaction?

_____

_____

(1)

(Total 6 marks)

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