Exothermic and Endothermic reactions 1

These practice questions can be used by students and teachers and is suitable for GCSE AQA Chemistry topic Questions 8462

Level: GCSE AQA Chemistry 8462

Subject: Chemistry

Exam board: GCSE AQA

Topic: Exothermic and Endothermic reactions 1

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 ☐

Glass is transparent ☐

Polystyrene is a better insulator ☐

Polystyrene is less dense ☐

(1)

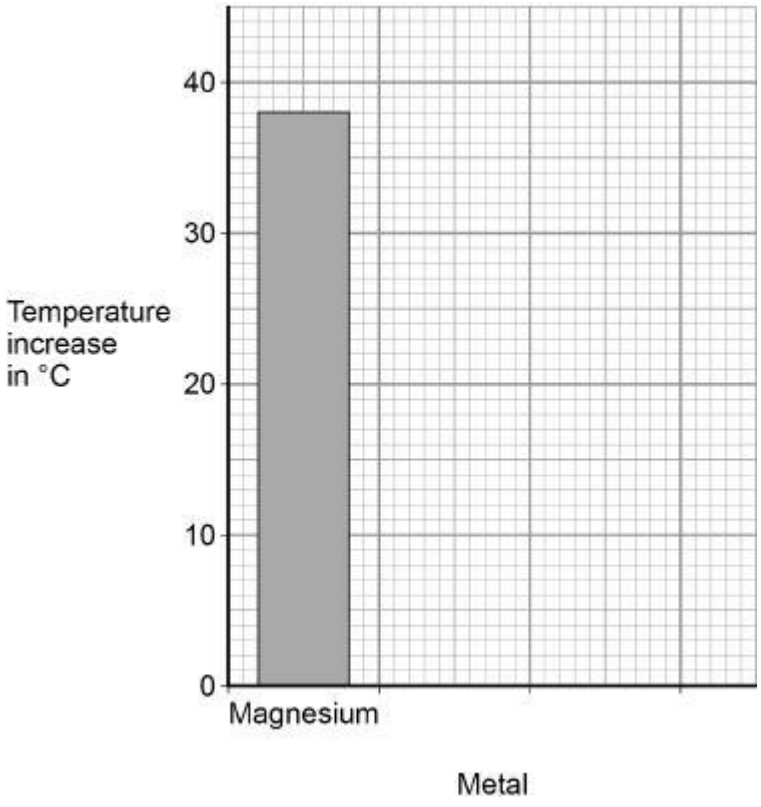
The table below shows the student's results.

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.

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)

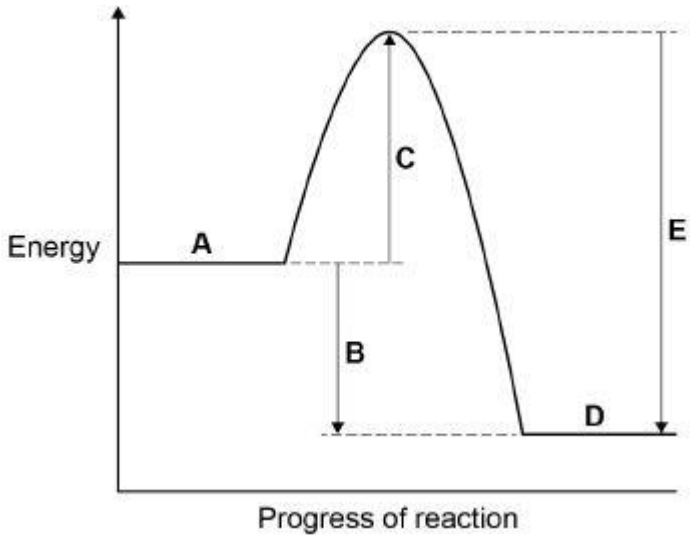
(f) **Y** is an unknown metal.

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



(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.

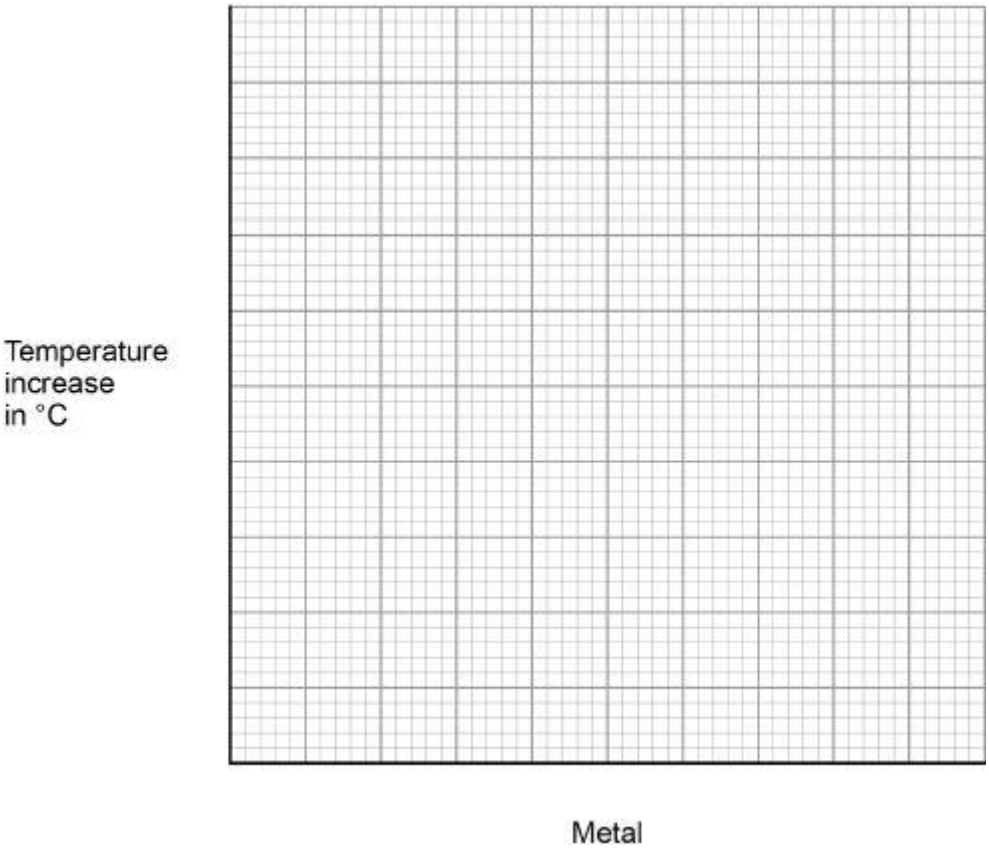
A student investigated the temperature change in displacement reactions between metals and copper sulfate solution.

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



(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.

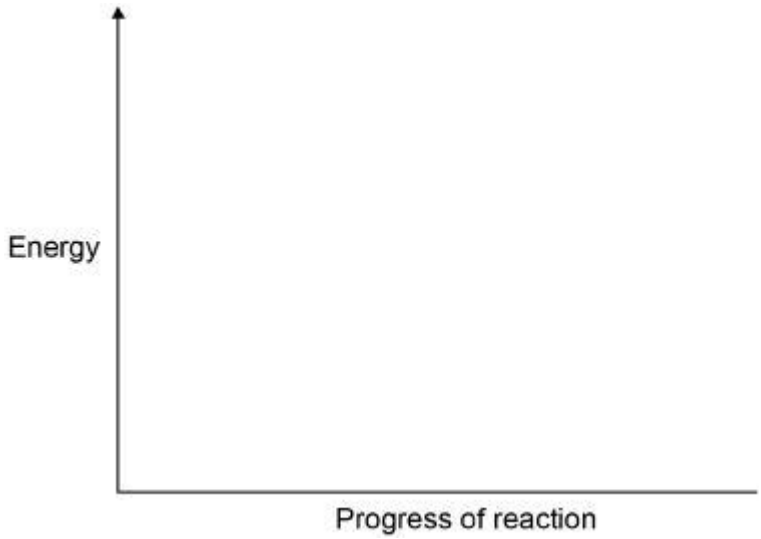
_____

_____

(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.

_____

_____

_____

_____

_____

_____

_____

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_____

_____

_____

(3)

(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.

_____

_____

_____

_____

_____

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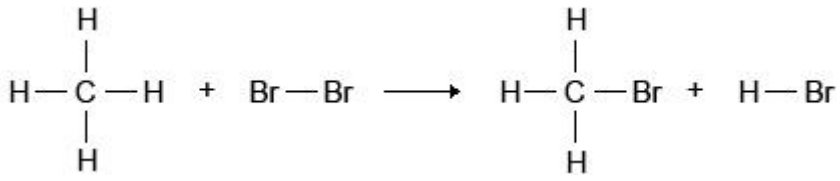
(3)

(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.

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

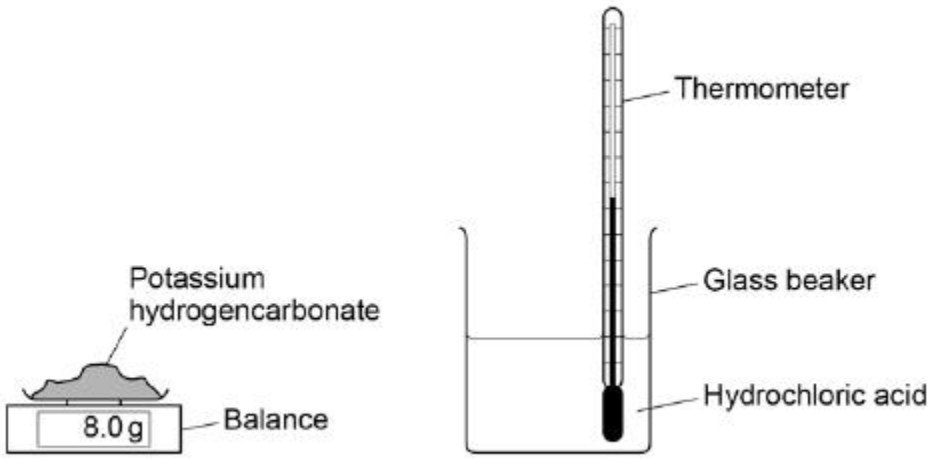
(4)
(Total 11 marks)

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 ☐

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.

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?

_____

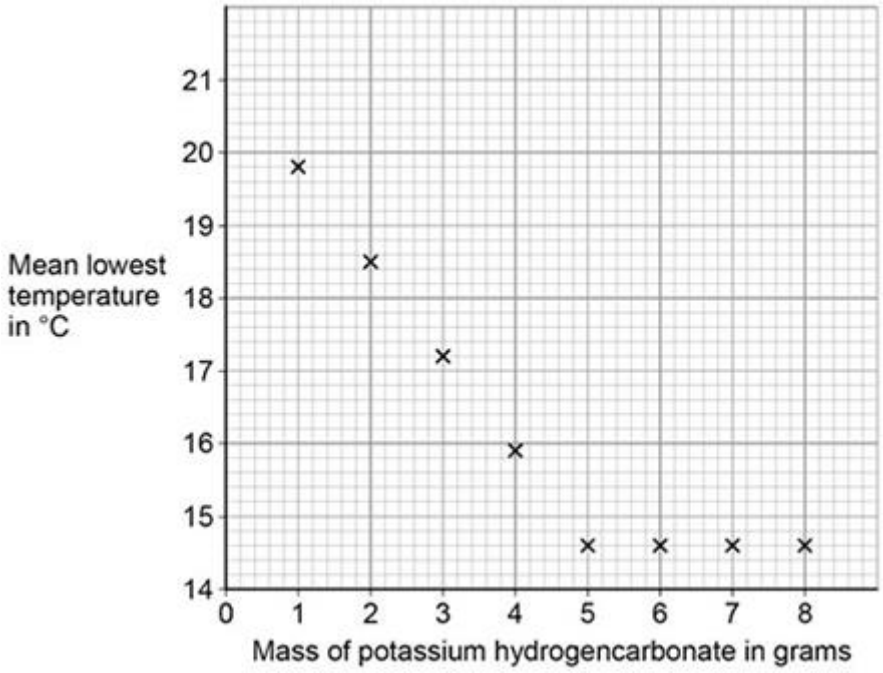
_____

_____

_____

(1)

The graph shows the student's results.



(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.

_____

_____

_____

_____

_____

_____

_____

_____

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_____

_____

_____

(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.
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.

_____

_____

_____

_____

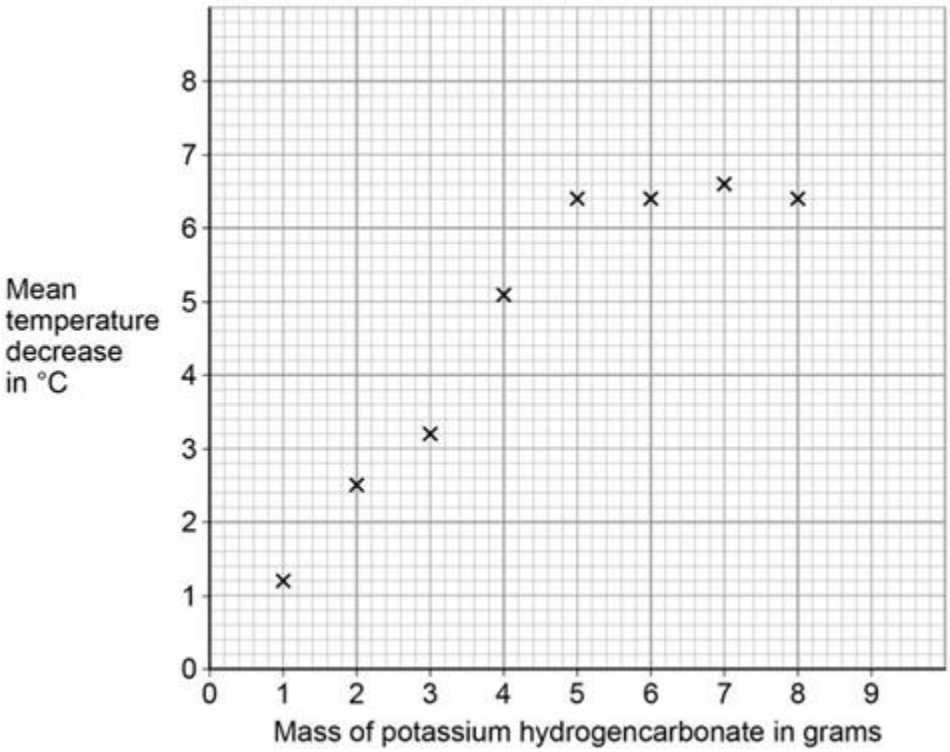
_____

_____

Mean = _____ °C ± _____ °C

(3)

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.

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?

_____

_____

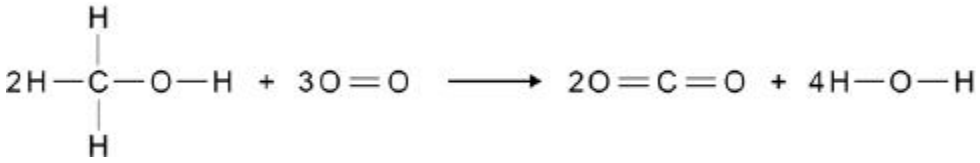
_____

_____

(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.

Overall energy change = _____ kJ / mol

(3)

(Total 8 marks)

Q7.

The figure below shows magnesium burning in air.

(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.

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.

_____

_____

_____

_____

(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:

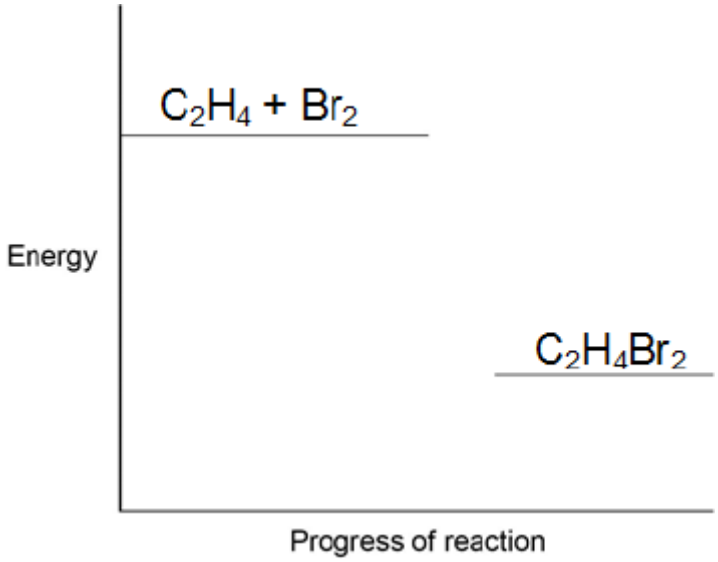
$$C_2H_4 + Br_2 \rightarrow C_2H_4Br_2$$

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

Draw labelled arrows to show:

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

Figure 1



(3)

(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.

_____

_____

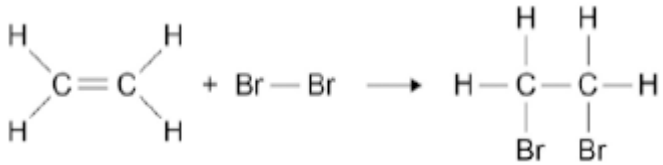
_____

_____

(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.

_____

_____

_____

_____

_____

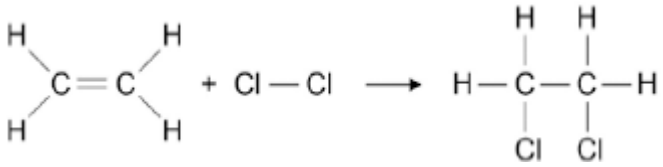
_____

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.”

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.

_____

_____

_____

_____

_____

_____

(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.

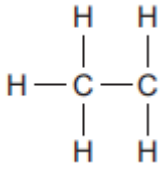
When alkenes react with bromine water the colour changes

from orange to _____ .

(1)

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

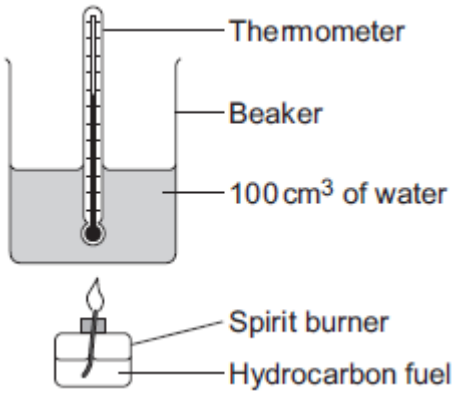
Complete the displayed structure of butane.



(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

(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.
- 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	47 kJ	142 kJ

combustion of 1 g of the fuel		

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)

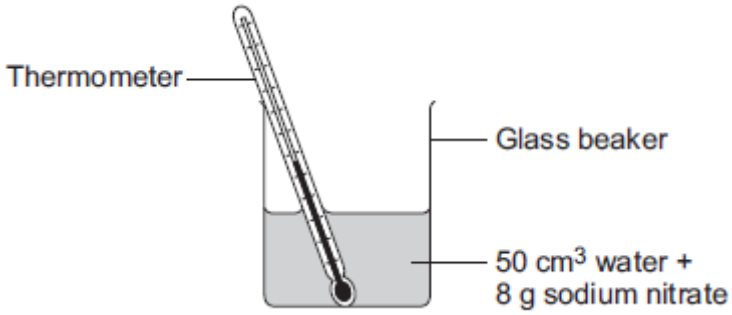
(Total 18 marks)

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
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.

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

_____

_____

_____

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_____

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_____

(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 _____

(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.**

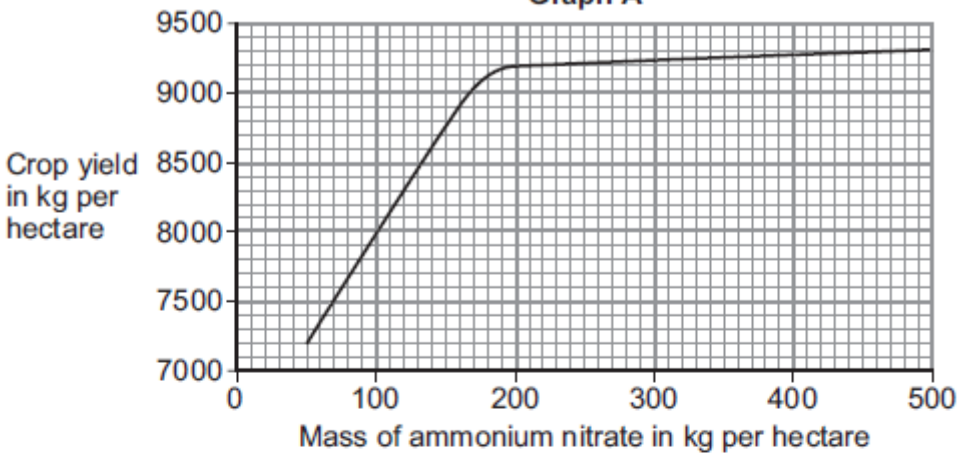
Farmers use ammonium nitrate as a fertiliser for crops.

Rainwater dissolves ammonium nitrate in the soil.

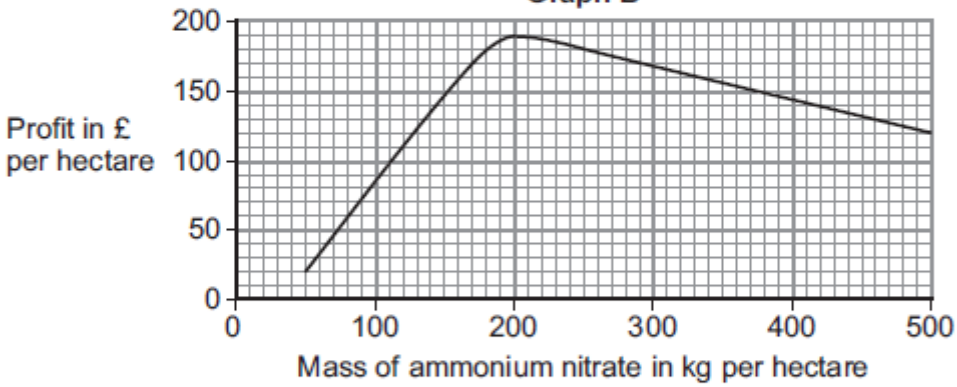
Some of the dissolved ammonium nitrate runs off into rivers and lakes.

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.

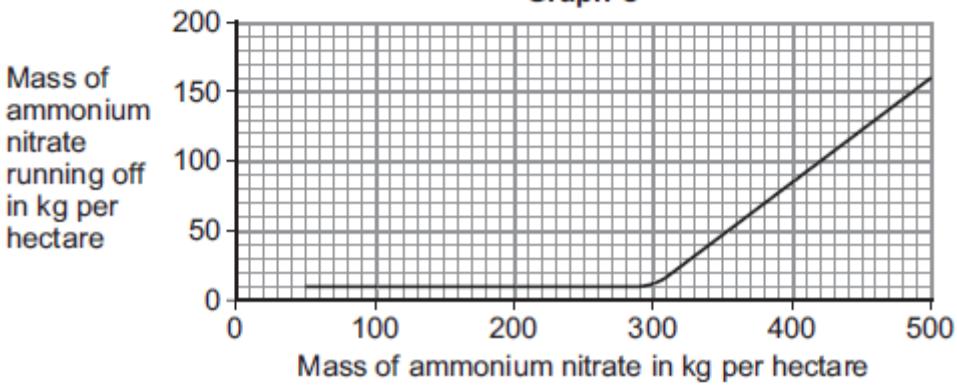
Graph A



Graph B



Graph C



Suggest how much ammonium nitrate farmers should use per hectare.

Give reasons for your answer.

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

_____

(6)

(Total 13 marks)

Q12.

This question is about energy changes in chemical reactions.

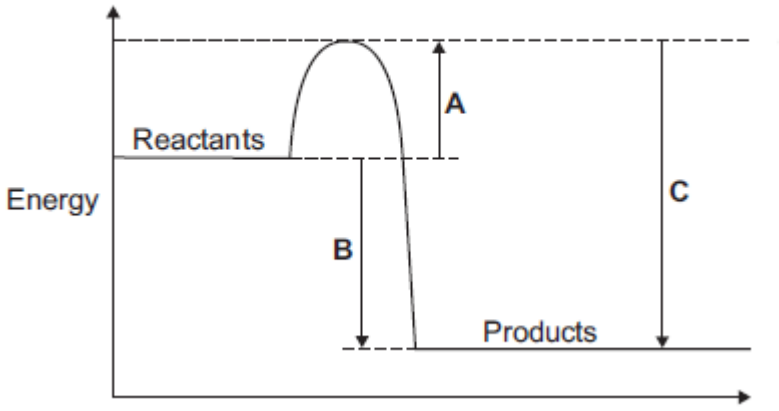
(a) Complete the word equation for the combustion of hydrogen.

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?

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

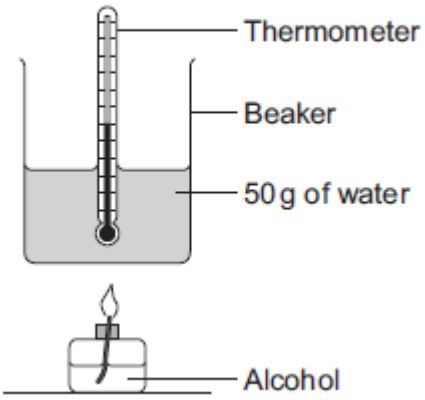
(1)

(c) Alcohols are used as fuels.

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

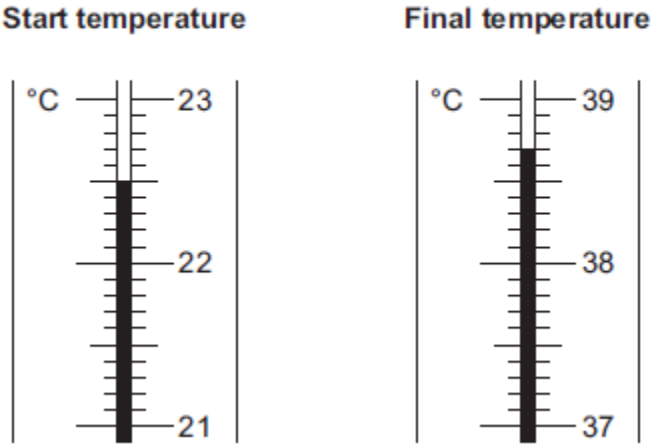
The students used the apparatus shown in **Figure 2**.

Figure 2



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

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

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.

_____

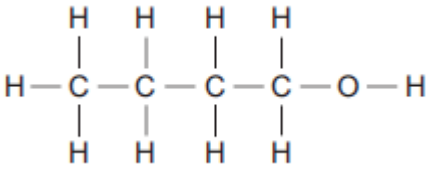
_____

_____

_____

(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.

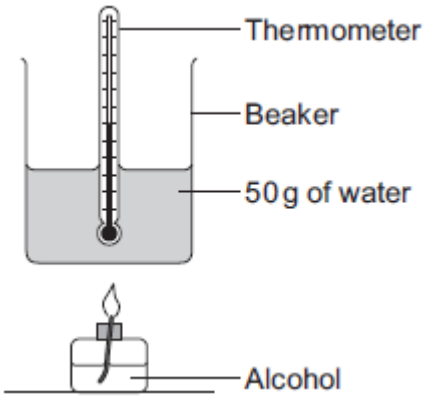
(a) Balance the chemical equation for the combustion of methane.

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

(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

_____

_____

_____

_____

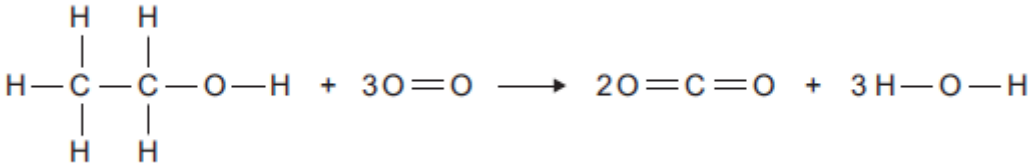
Heat energy (Q) = _____ J

(3)

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

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

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



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)

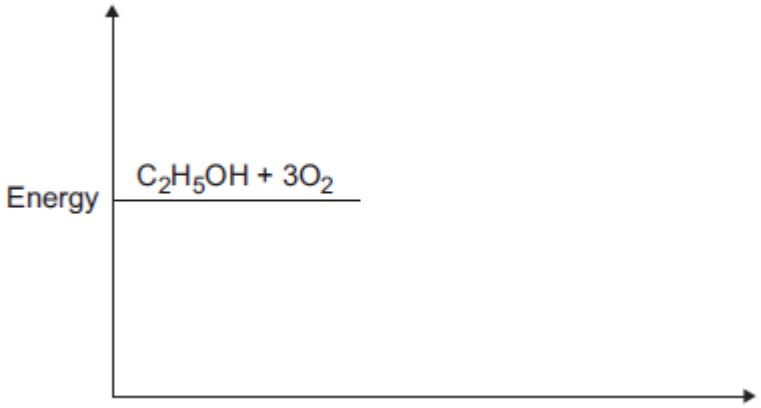
(ii) The reaction is exothermic.
Explain why, in terms of bonds broken and bonds formed.

(2)

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

On the completed diagram, label:

- activation energy
- overall energy change.



(3)

(Total 12 marks)

Q14.

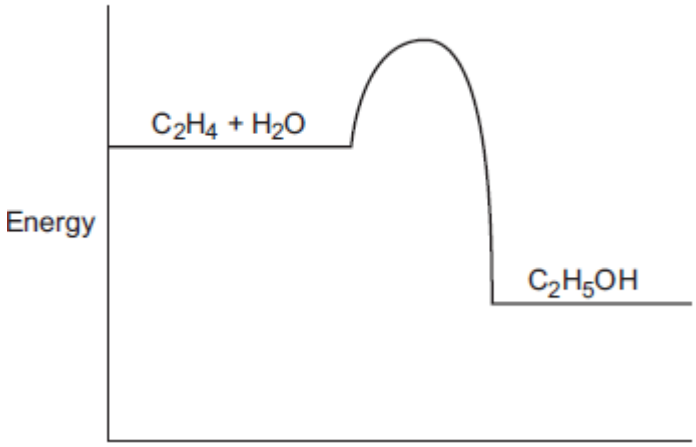
This question is about ethanol.

(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.

_____

_____

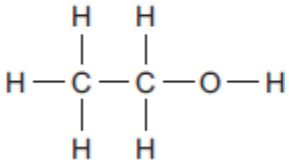
_____

_____

(2)

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

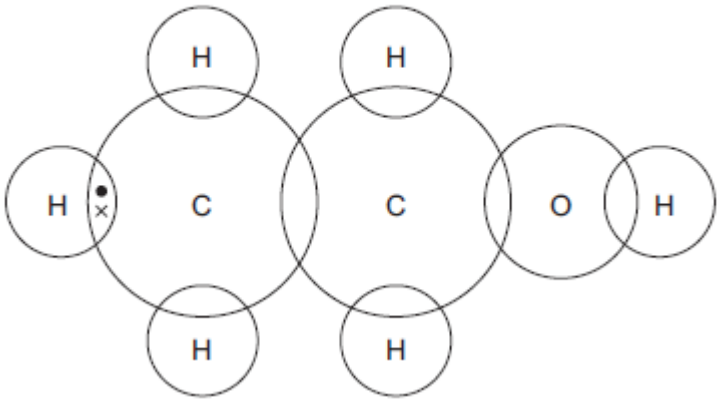
Figure 2



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

Show the outer shell electrons only.

Figure 3

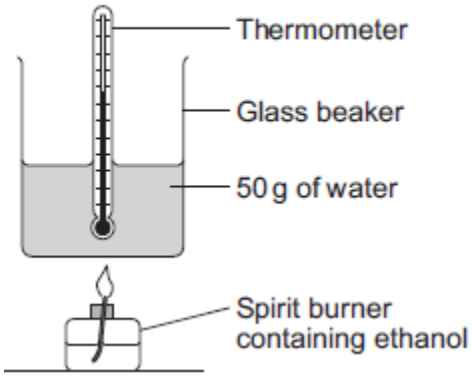


(2)

(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

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.

_____

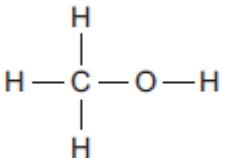
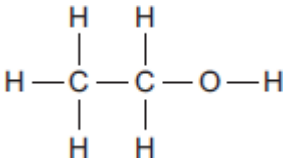
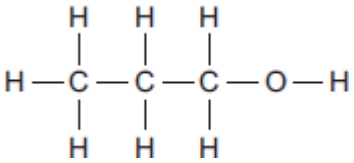
_____

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.

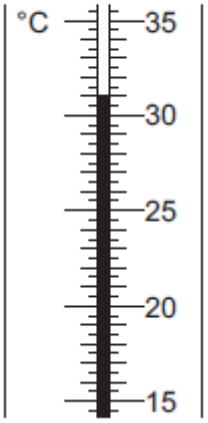
Step 1 Put 25 cm^3 of dilute nitric acid in a polystyrene cup.

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.
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?

_____

_____

_____

_____

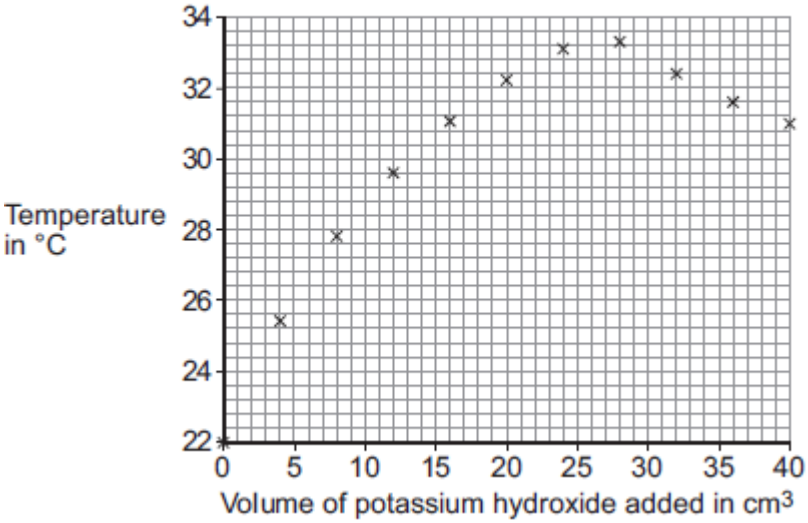
_____

_____

(1)

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

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.

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

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.

_____

_____

_____

_____

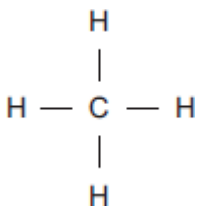
(2)

(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)

(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. ☐

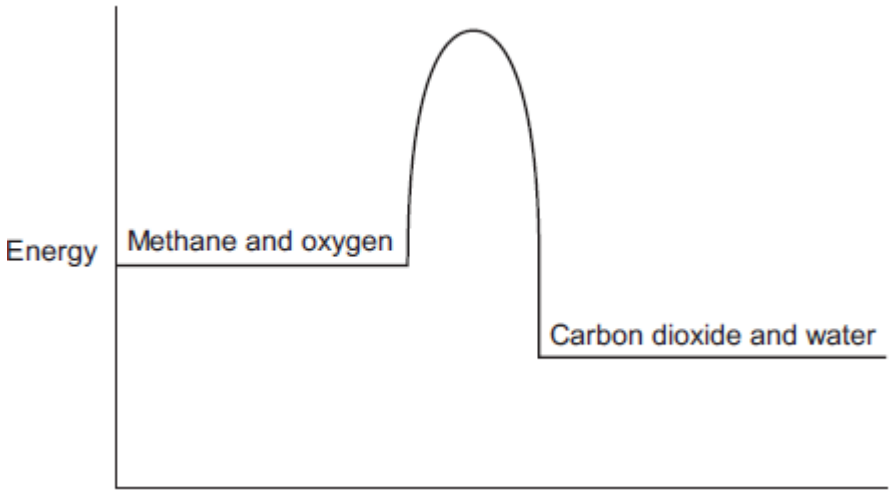
(1)

(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.

(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)

(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)

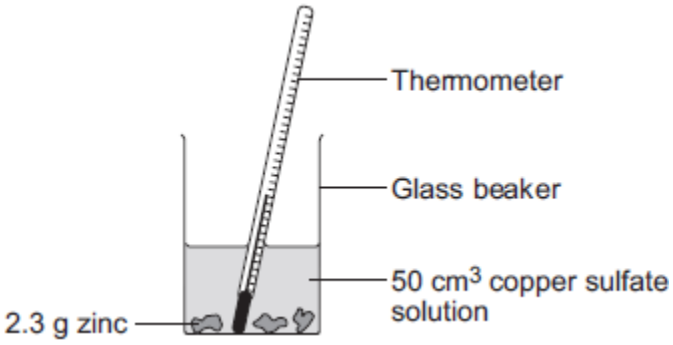
(Total 15 marks)

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
- 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
8	0.8	35
9	0.9	35
10	1.0	35

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

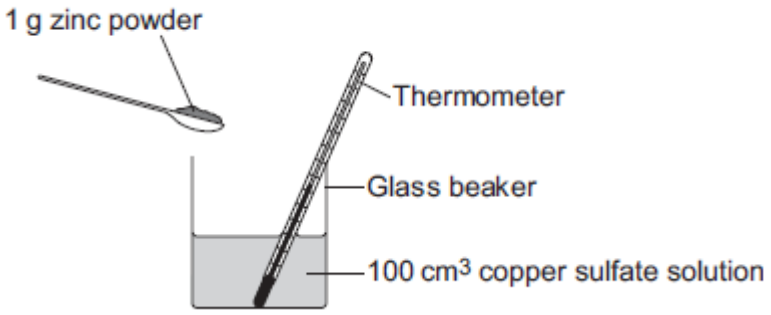
(6)

(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
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?

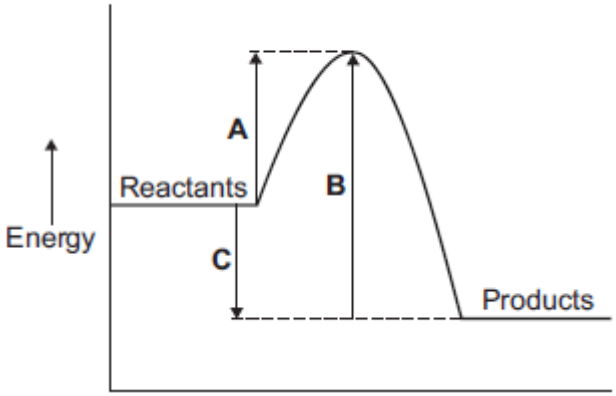
_____

_____

(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)

(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.

_____

_____

_____

(2)

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

Give a reason for your answer.

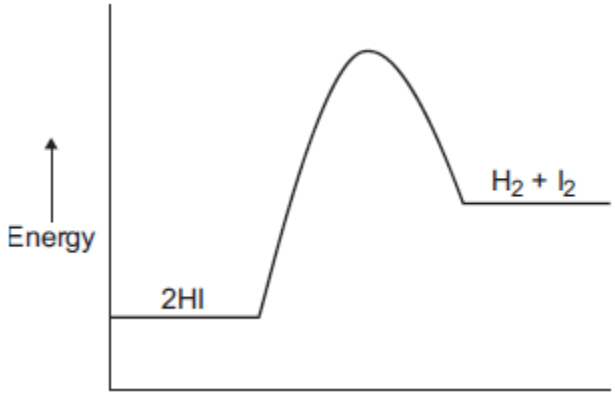
(2)

(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.

Give a reason for your answer.

_____

_____

_____

_____

_____

_____

_____

_____

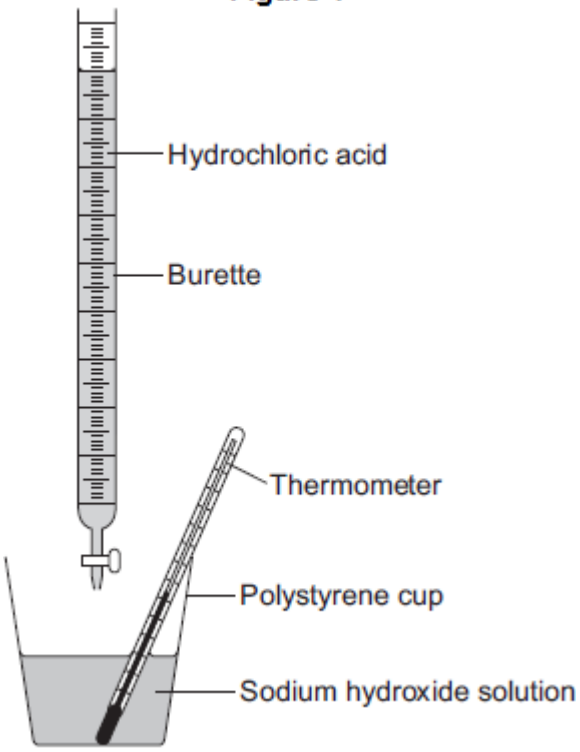
(2)

(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:

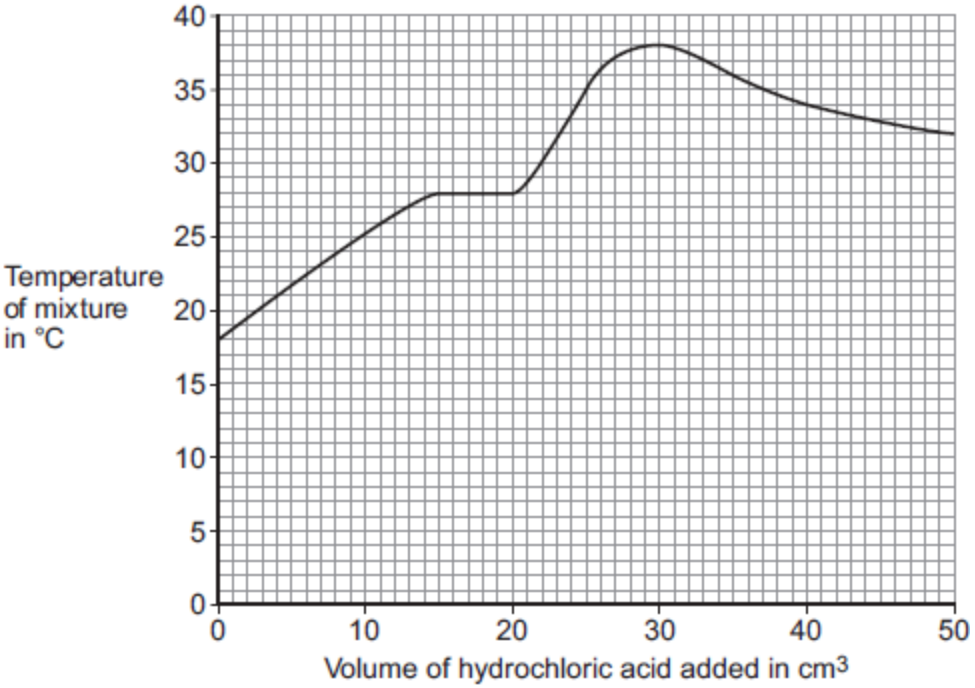
- measures 25 cm^3 sodium hydroxide solution into a polystyrene cup
- fills a burette with hydrochloric acid
- measures the temperature of the sodium hydroxide solution
- adds 5 cm^3 hydrochloric acid to the sodium hydroxide solution in the polystyrene cup
- stirs the mixture and measures the highest 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**.

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
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.

_____

_____

_____

_____

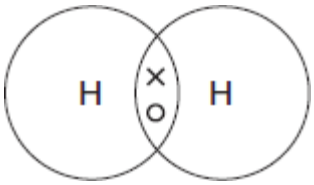
(2)

(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.

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.

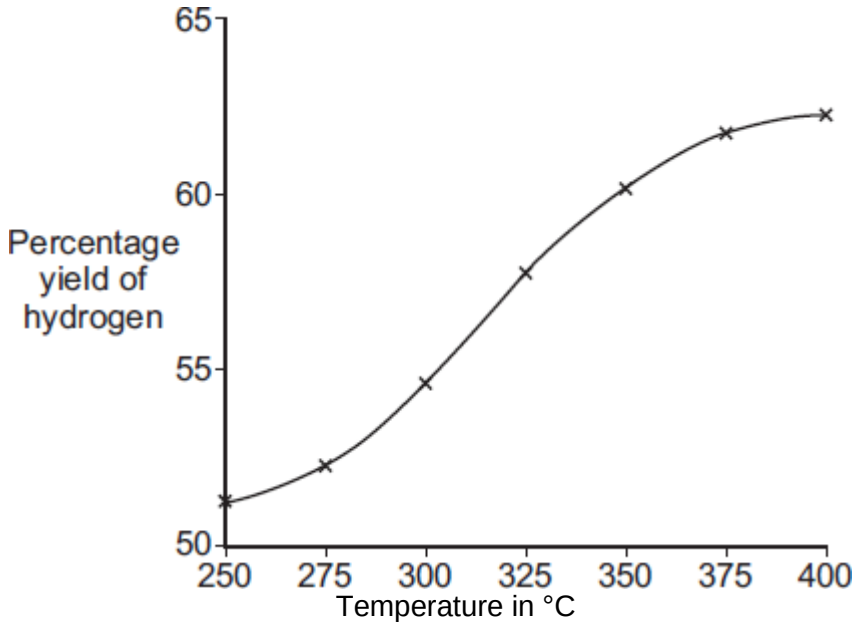
_____

_____

_____

(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?

(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.

Extra space

(6)

(Total 13 marks)

Q22.

The equation for the reaction of ethene and bromine is:

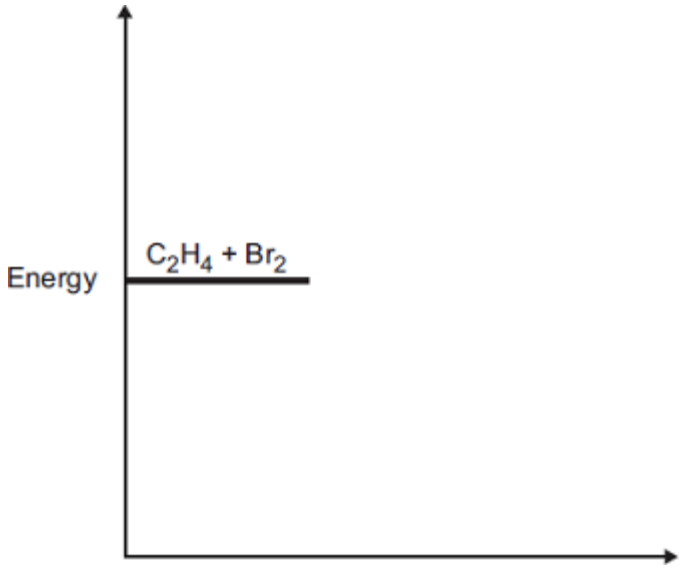
$$C_2H_4(g) + Br_2(l) \longrightarrow C_2H_4Br_2(l)$$

The reaction is exothermic.

(a) Complete the energy level diagram.

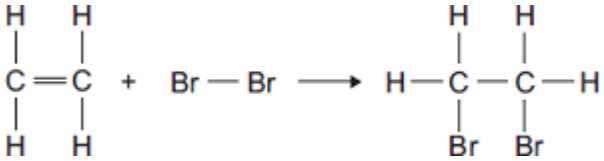
You should label:

- 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
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.

(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)

Q24.

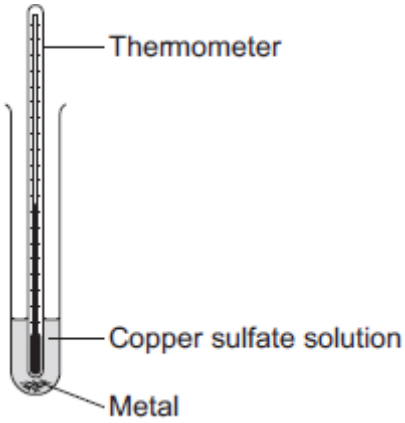
A student investigated displacement reactions of metals.

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. _____

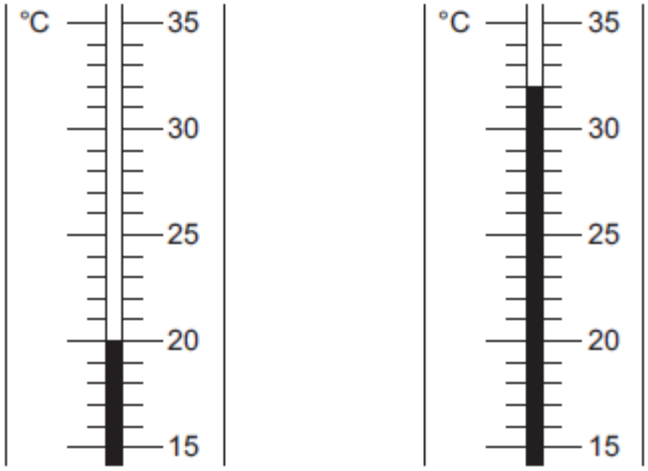
3. _____

(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**



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.

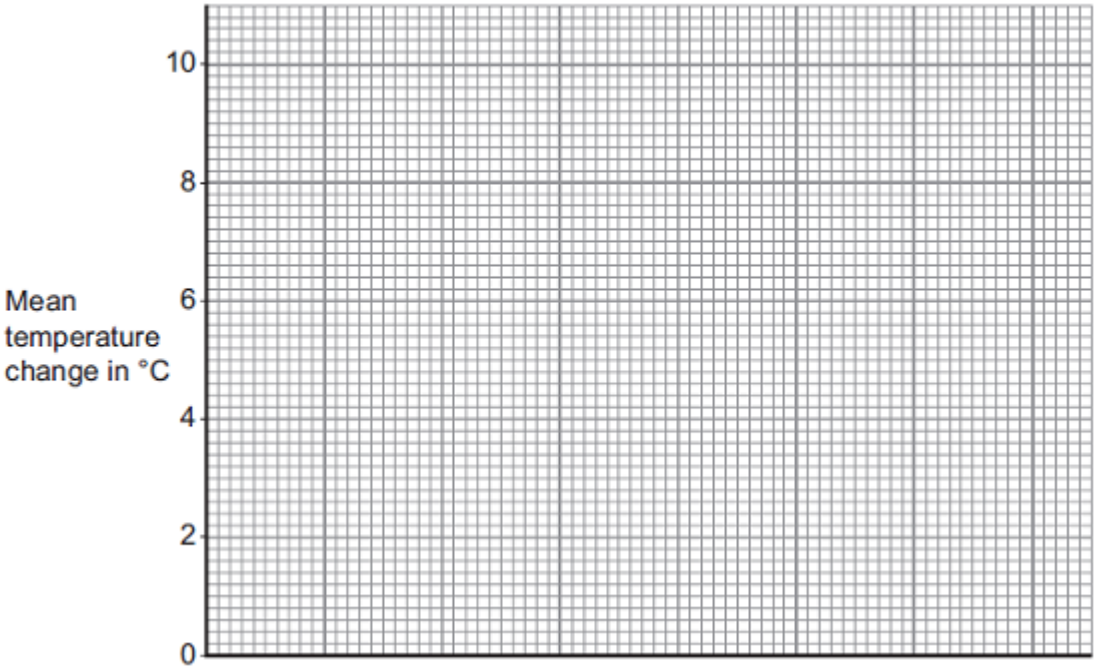
Table 2 shows the mean temperature change for each metal.

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



(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.

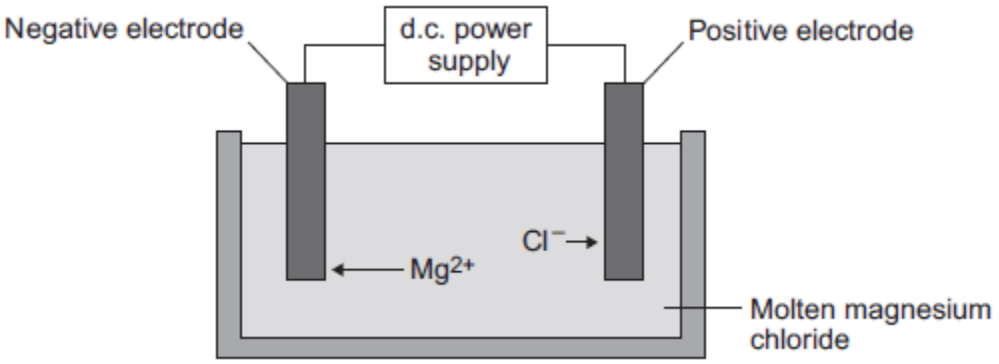
(2)

(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.

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.

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

_____

_____

_____

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.

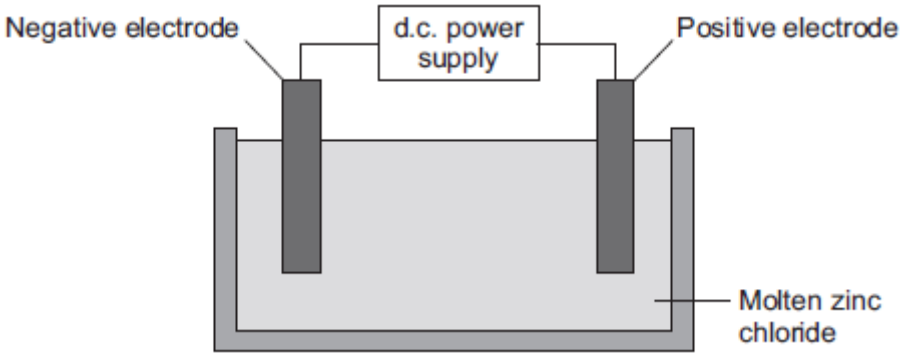
(1)

(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?

_____

_____

_____

_____

(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

_____

_____

_____

_____

_____

_____

_____

_____

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

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

Draw a ring around the correct answer.

chemical **electrical** **light**

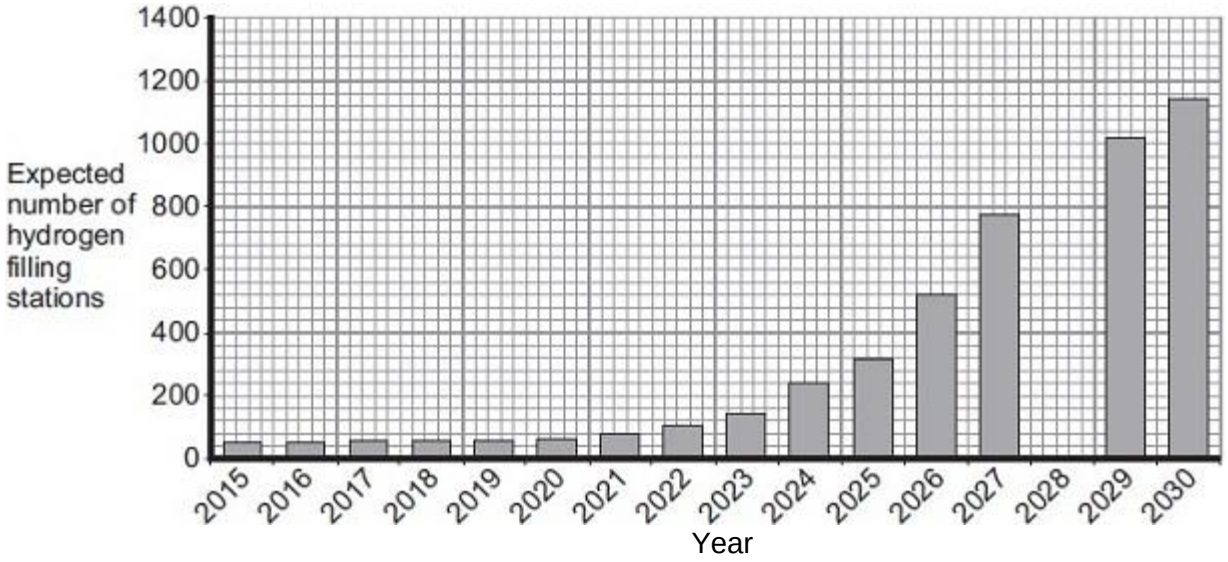
(1)

(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.

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.

_____

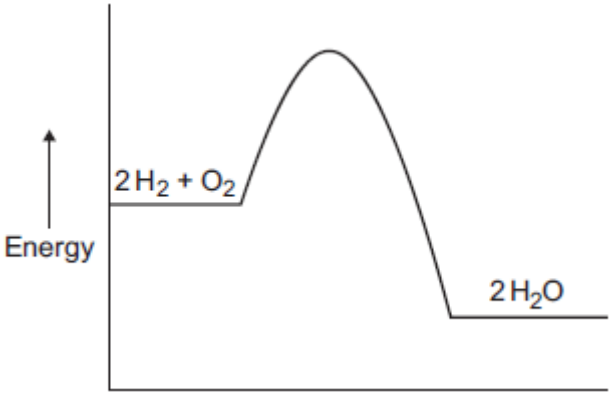
_____

(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)

Q28.

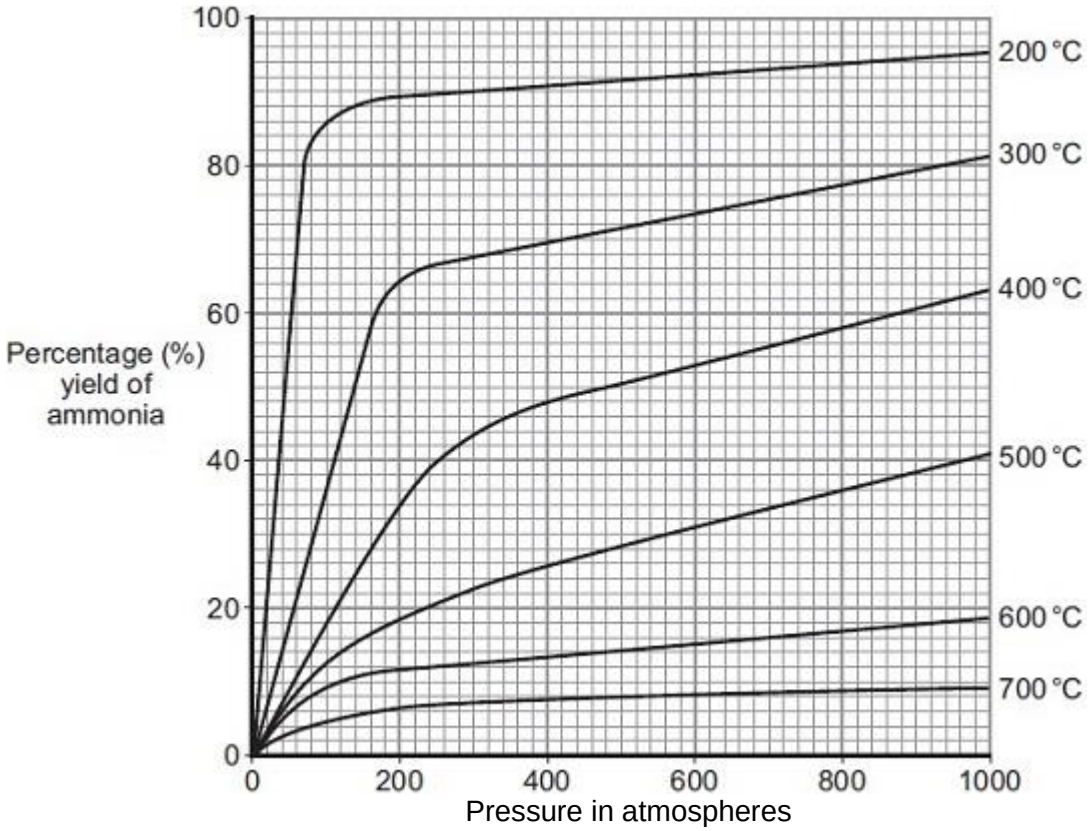
In 1909 Fritz Haber invented a process to produce ammonia from nitrogen and hydrogen.

(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.

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

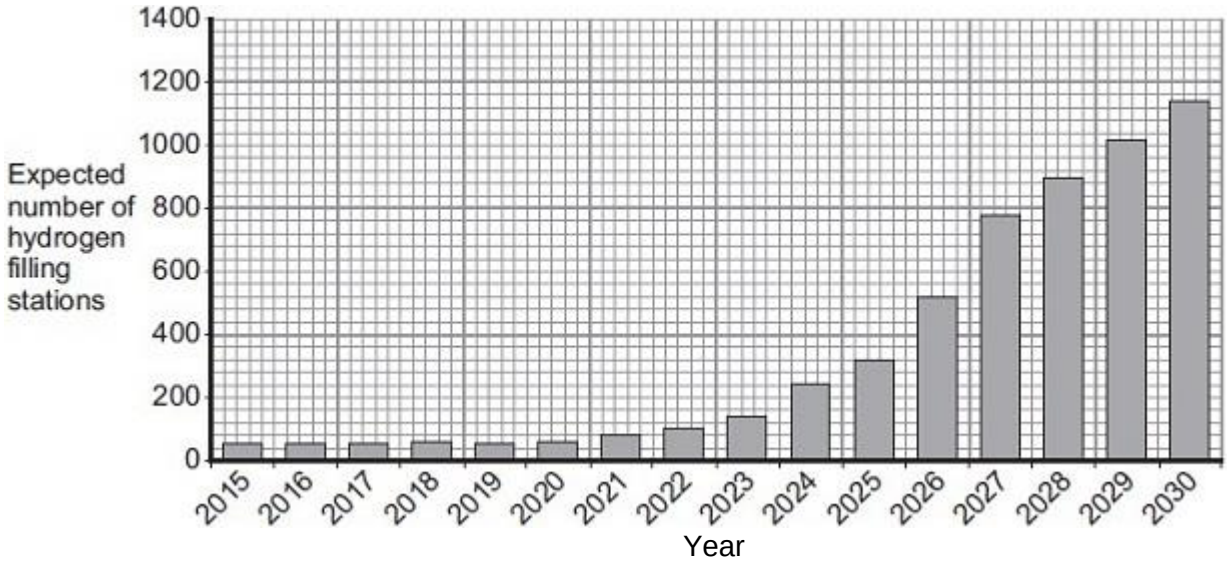
(a) What type of energy is released by hydrogen fuel cells?

(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.

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:

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

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

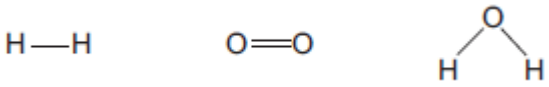
Energy is released when new bonds are made to form the product.

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



hydrogen oxygen water

(i) Calculate the energy change for the reaction:

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

Energy change = _____ kJ

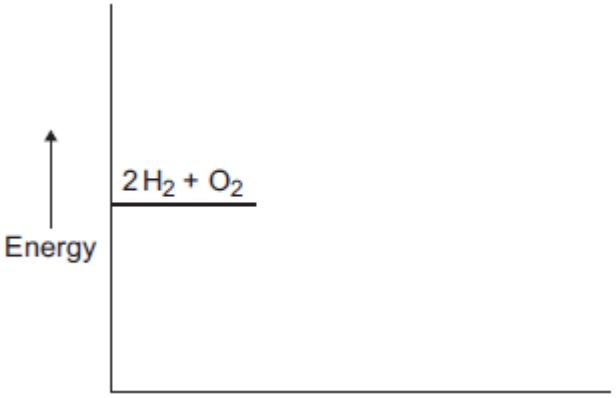
(3)

(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.

(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

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)

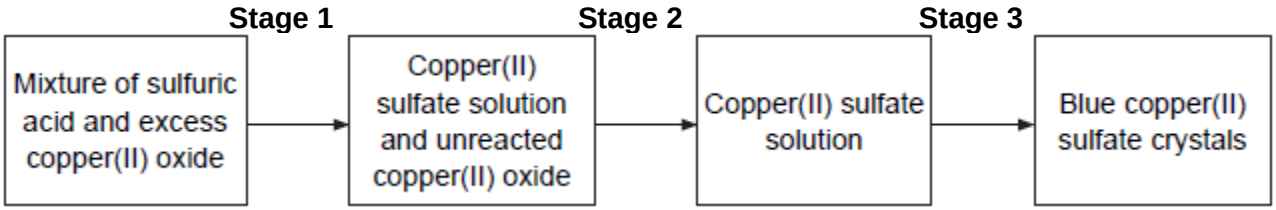
(Total 9 marks)

Q31.

This question is about compounds of copper.

(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 $\rightleftharpoons$ anhydrous copper(II) sulfate + water

blue white

(i) What does the symbol $\rightleftharpoons$ mean ?

_____

_____

(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.

© Ethan Daniels/Shutterstock

(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)

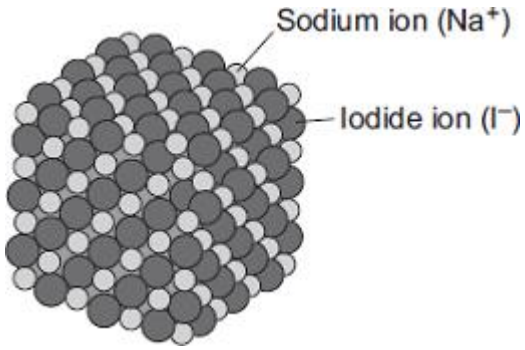
(ii) Sodium iodide contains sodium ions (Na^+) and iodide ions (I^-).

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

(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.

$$\_\_\_\_\_I^- \rightarrow I_2 + \_\_\_\_\_e^-$$

(1)

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

Explain why.

_____

_____

_____

_____

(2)

(Total 11 marks)

Q33.

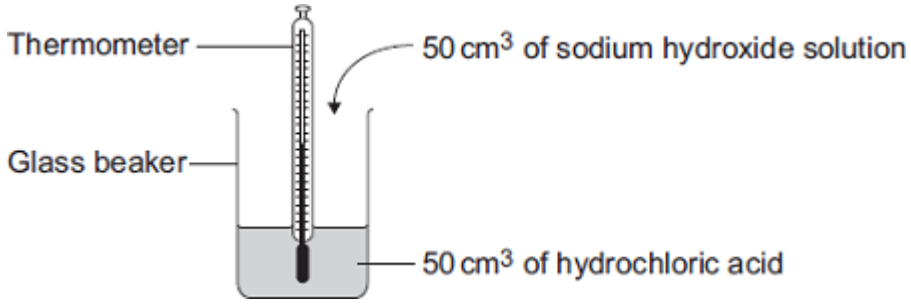
Read the information about energy changes and then answer the questions.

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 change in °C	7.2	7.0	6.8	4.5

(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.

Diagram A

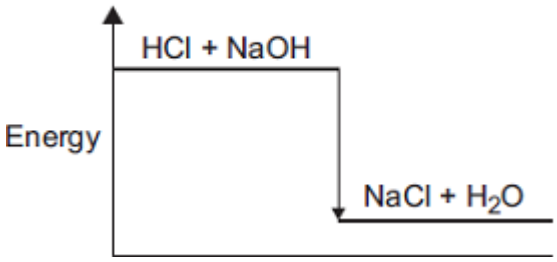
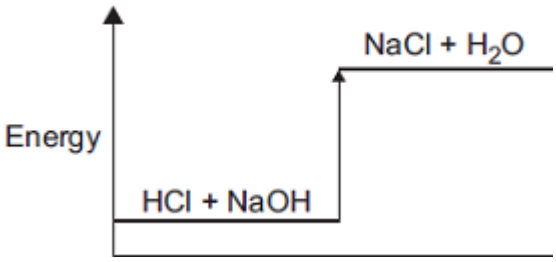


Diagram B



_____

_____

_____

_____

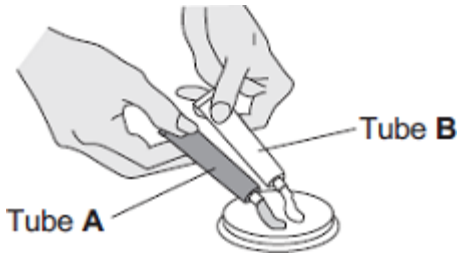
(1)

(Total 7 marks)

Q34.

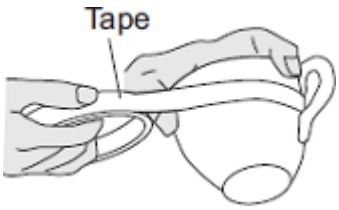
The following steps show how to use a type of glue.

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?

_____
_____

_____
_____

_____
_____

_____
_____

(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)

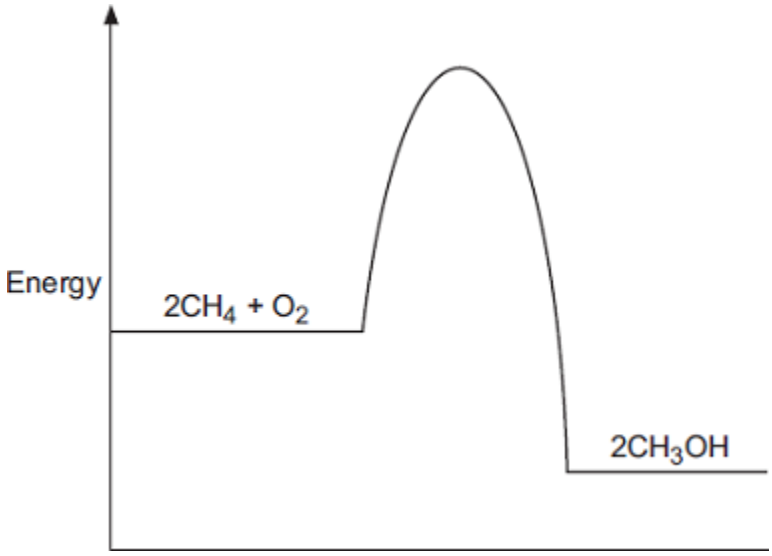
Q35.

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

The equation for the reaction is:

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

(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?

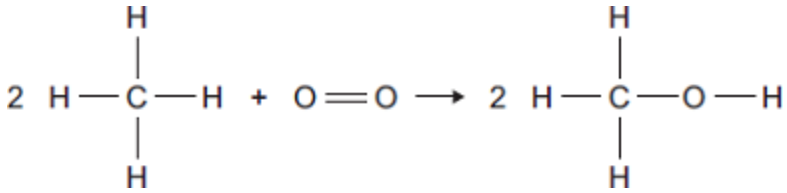
_____

_____

_____

(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
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?

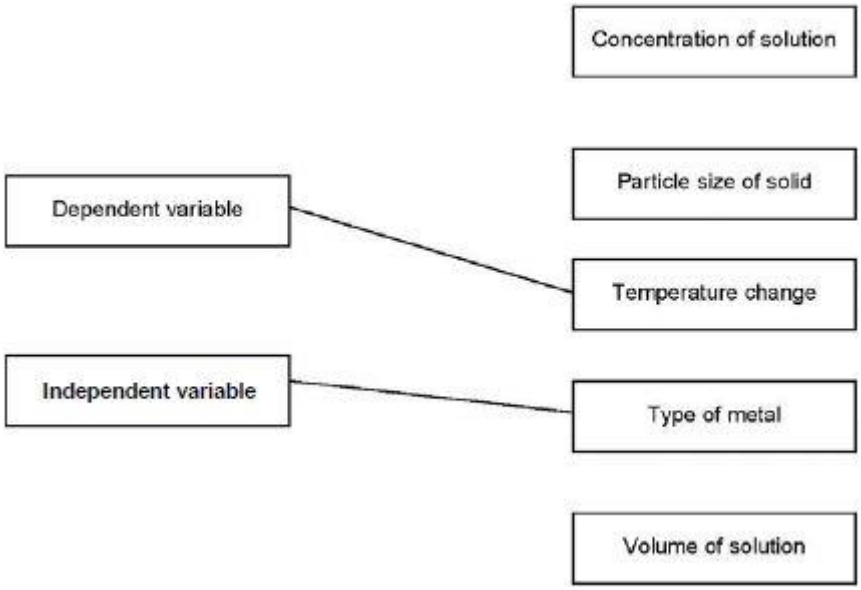
(1)

(Total 6 marks)

Mark schemes

Q1.

(a)



*allow **one** mark if answers are reversed*

1
1

(b) polystyrene is a better insulator

1

(c) both bars labelled

1

both bars correctly plotted

allow tolerance of ±½ small square

ignore width and spacing of bars

*if no other mark scored, allow **1** mark for any one bar correctly plotted and labelled*

1

(d) temperature increases

allow (because) energy / 'heat' is transferred to the surroundings

or

temperature does not decrease

energy / 'heat' is not taken in from the surroundings

allow the energy of the products is less than the energy of the reactants

1

(e) (most reactive)

magnesium

(zinc)

nickel

this order only

1

(f) suitable method described

1

the observations / measurements required to place in order

1

an indication of how results would be used to place the unknown metal in the reactivity series

1

approaches that could be used:

approach 1:
add the unknown metal to copper sulfate solution (1)

measure temperature change (1)

place the metals in order of temperature change (1)

approach 2:
add the metal to salt solutions of the other metals
or
heat the metal with oxides of the other metals (1)

measure temperature change (only if salt solutions used)
or
observe whether a chemical change occurs (1)

compare temperature change or whether there is a reaction to place in correct order (1)

approach 3:
add all of the metals to an acid (1)

measure temperature change or means of comparing rate of reaction (1)

place the metals in order of temperature change or rate of reaction (1)

approach 4:
set up electrochemical cells with the unknown metal as one electrode and each of the other metals as the other electrode (1)

measure the voltage of the cell (1)

place the metals in order of voltage (1)

(g) D

1

(h) C

1

[12]

Q2.

(a) all 4 metals labelled and suitable scale on *y*-axis

magnesium value must be at least half the height of the grid

1

all bars correctly plotted

allow a tolerance of ±½ a small square

ignore width and spacing of bars

*allow **1** mark if copper not included and other 3 bars plotted correctly*

1

(b) temperature increases

allow (because) energy / 'heat' is transferred to the surroundings
allow energy / 'heat' is given out

or

temperature does not decrease

allow energy / 'heat' is not taken in (from the surroundings)
allow the energy of the products is less than the energy of the reactants

1

ignore because it is exothermic
ignore references to copper

(c) suitable method described

1

the observations / measurements required to place in order

dependent on a suitable method

1

an indication of how results would be used to place the unknown metal in the reactivity series

1

a control variable to give a valid result

1

approaches that could be used

approach 1:
add the unknown metal to copper sulfate solution (1)

measure temperature change (1)

place the metals in order of temperature change (1)

any **one** from (1):
- same volume of solution
- same concentration of solution
- same mass / moles of metal
- same state of division of metal

approach 2:
add the metal to salt solutions of the other metals
or
heat the metal with oxides of the other metals (1)

measure temperature change (only if salt solutions used)
or
observe whether a chemical change occurs (1)

place the metals in order of temperature change **or**
compare whether there is a reaction to place in correct order (1)

any **one** from (1):
- same volume of salt solutions
- same concentration of salt solutions
- same (initial) temperature of salt solutions
- same mass / moles of metal **or** metal oxide
- same state of division of metal **or** metal oxide

approach 3:
add all of the metals to an acid (1)

measure temperature change or means of comparing rate of reaction (1)

place the metals in order of temperature change or rate of reaction (1)

any **one** from (1):
- same volume of acid
- same concentration of acid
- same (initial) temperature of acid
- same mass / moles of metal
- same state of division of metal

approach 4:
set up electrochemical cells with the unknown metal as one electrode and each of the other metals as the other electrode (1)

measure the voltage of the cell (1)

place the metals in order of voltage (1)

any **one** from (1):
- same electrolyte
- same concentration of electrolyte
- same (initial) temperature of acid
- same temperature of electrolyte

(d) correct shape for exothermic reaction

the reactant and product lines needed not be labelled

*do **not** accept incorrectly labelled reactant and product lines*

1

labelled activation energy

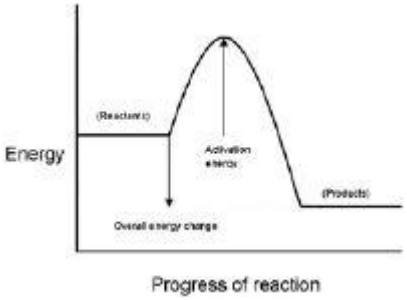
1

labelled (overall) energy change

1

ignore arrow heads

an answer of:



*scores **3** marks*

[10]

Q3.

(a) potassium chloride **and** iodine

either order

allow KCl for potassium chloride and I_2 for iodine

1

(b) (chlorine's) outer electrons / shell closer to the nucleus

allow chlorine has fewer shells

allow chlorine atom is smaller than iodine atom

ignore chlorine has fewer outer shells

1

(so) the chlorine nucleus has greater attraction for outer electrons / shell

allow chlorine has less shielding

*do **not** accept incorrect types of attraction*

1

(so) chlorine gains an electron more easily

1

***max 2** marks can be awarded if the answer refers to chloride / iodide instead of chlorine / iodine*

allow converse statements

allow energy levels for shells throughout

(c) hydrogen chloride is made of small molecules

allow hydrogen chloride is simple molecular

1

(so hydrogen chloride) has weak intermolecular forces*

1

(intermolecular forces) require little energy to overcome*

1

*do **not** accept reference to bonds breaking unless applied to intermolecular bonds*

(d) (bonds broken = 4(412) + 193 =)1841

1

(bonds formed = 3(412) + 366 + **X** =) 1602 + **X**

1

−51 = 1841 − (1602 + **X**)

allow use of incorrectly calculated values of bonds broken and / or bonds formed from steps 1 and 2 for steps 3 and 4

1

(**X** =) 290 (kJ/mol)

allow a correctly calculated answer from use of −51 = bonds formed − bonds broken

1

OR

alternative method ignoring the 3 unchanged C−H bonds

(412 + 193 =) 605 (1)

366 + **X** (1)

−51 = 605 − (366 + **X**) (1)

(**X** =) 290 (kJ/mol) (1)

*an answer of 290 (kJ/mol) scores **4** marks*

*an answer of 188 (kJ/mol) scores **3** marks*

*an incorrect answer for one step does **not** prevent allocation of marks for subsequent steps*

[11]

Q4.

(a) measuring cylinder

1

(b) use a polystyrene cup

allow insulate the beaker and / or use a lid

1

better insulator

or

reduces energy transfer from the surroundings

1

(c) starting temperature of hydrochloric acid

1

volume of hydrochloric acid

1

(d) 21.4 (°C)

1

(e) 15.8 (°C) to 16.1 (°C)

allow 16.1 (°C) to 15.8 (°C)

1

(f) $\frac{16.1 + 15.8 + 15.9}{3}$

=15.9 (°C)

*an answer of 15.9(333..) (°C) scores **2** marks*

1

allow 15.9(333..) (°C)

1

(g) temperature decreases

1

(h) straight line from (1.0, 19.8) to (5.0, 14.6)

ignore continuation of line in either direction

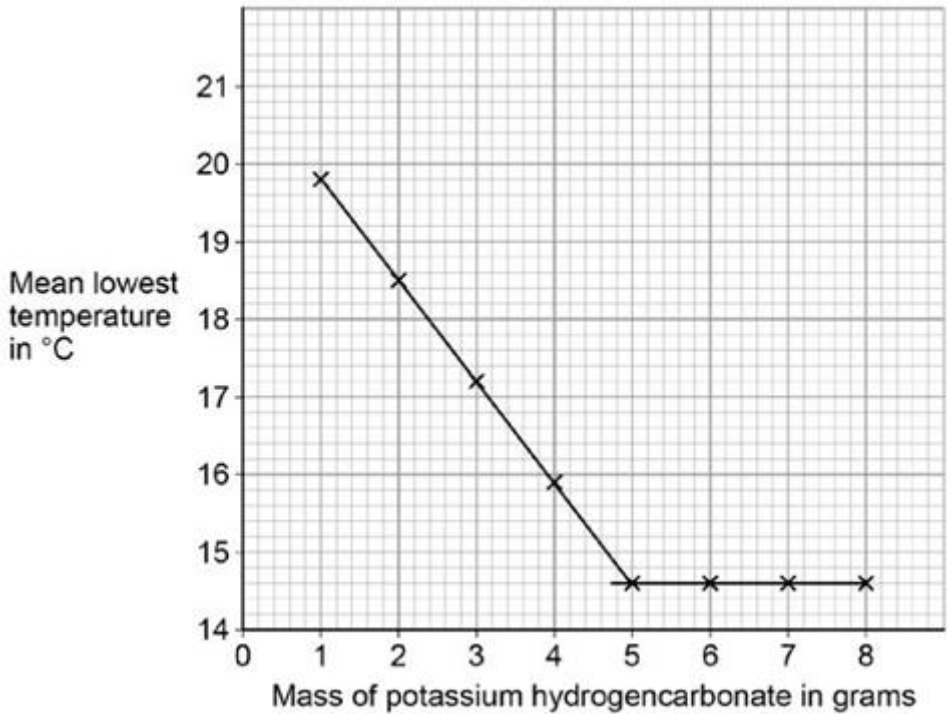
1

horizontal straight line from (5.0, 14.6 to 8.0, 14.6)

ignore continuation of line in either direction

1

the answer below scores **2** marks



(i) (lowest) temperature decreases

1

to 14.6 °C
or
until 5 g added

1

then no change to temperature (after 5 g solid added)
or
then temperature remains at 14.6 °C (after 5 g solid added)

1

[15]

Q5.

(a) use a polystyrene cup instead of a (glass) beaker

allow insulate the beaker
allow use a lid

1

minimises energy transfer from the surroundings
or
for better insulation

1

(b) concentration of hydrochloric acid

1

(c) $\frac{5.6 + 5.7 + 5.4}{3}$

1

= 5.6 (°C)

1

± 0.2

1

(d) straight line from origin to (5.0, 6.4)

must not deviate to anomalous point

1

horizontal line from (5.0, 6.4) to (8.0, 6.4)

must not deviate to anomalous point

1

(e) as mass (of potassium hydrogencarbonate) increases, temperature decrease / change increases

1

until 5 g (to 8 g) (of potassium hydrogencarbonate has been added)

allow ecf from lines of best fit

1

(because) the reaction has finished
or
(because) all the acid has reacted
or
(because) no more solid can react
or
(because) the solid is in excess

1

(f) not stirred correctly

1

[12]

Q6.

(a) the chemical reaction is reversible

1

(b) any **two** from:

- type of electrode
- electrolyte
- concentration of electrolyte
- temperature

2

(c) $H_2 + \mathbf{2}OH^- \rightarrow \mathbf{2}H_2O + \mathbf{2}\ e^-$

allow multiples

1

(d) contains OH^- ions

1

(e) (bonds broken)

((6 × 412) + (2 × 360) + (2 × 464) + (3 × 498)) = 5614

1

(bonds made)
((4 × 805) + (8 × 464)) = 6932

1

(overall energy change)
(6932 − 5614) = −1318 (kJ / mol)

allow ecf from marking point 1 and / or marking point 2

1

*an answer of 1318 (kJ / mol) scores **3** marks*

[8]

Q7.

(a) any **one** from:

- there was a flame
- energy was given out
- a new substance was formed
- the magnesium turned into a (white) powder

answers must be from the figure

1

(b) Magnesium oxide

1

(c) The reaction has a high activation energy

1

(d) 9

1

(e) They have a high surface area to volume ratio

1

(f) any **one** from:

- Better coverage
- More protection from the Sun's ultraviolet rays

1

(g) any **one** from:

- Potential cell damage to the body
- Harmful effects on the environment

1

(h) indication of $\frac{1}{1.6}$ = 0.625
and
use of indices $10^{-9} - 10^{-6} = 10^{3}$

Both steps must be seen to score first mark

1

0.625 × 1000 = 625 (times bigger)

1

[9]

Q8.

(a) line goes up before it goes down

1

energy given out correctly labelled

1

activation energy labelled correctly

1

(b) electrostatic force of attraction between shared pair of negatively charged electrons

1

and both positively charged nuclei

1

(c) bonds formed = 348 +4(412) + 2(276) = 2548 kJ / mol

1

bonds broken − bonds formed = 612 + 4(412) + (Br-Br) − 2548 = 95 kJ / mol

1

Alternative approach without using C-H bonds
For step 1 allow = 348 + 2(276) = 900 kJ / mol
Then for step 2 allow 612 + (Br-Br) − 900 = 95 kJ / mol

193 (kJ / mol)

1

*accept (+)193 (kJ / mol) with no working shown for **3** marks*
*−193(kJ / mol) scores **2** marks*
allow ecf from step 1 and step 2

(d) **Level 3 (5–6 marks):**
A detailed and coherent explanation is given, which demonstrates a broad understanding of the key scientific ideas. The response makes logical links between the points raised and uses sufficient examples to support these links. A conclusion is reached.

Level 2 (3–4 marks):
An explanation is given which demonstrates a reasonable understanding of the key scientific ideas. A conclusion may be reached but the logic used may not be clear or linked to bond energies.

Level 1 (1–2 marks):
Simple statements are made which demonstrate a basic understanding of some of the relevant ideas. The response may fail to make logical links between the points raised.

0 marks:
No relevant content.

Indicative content

Size and strength

- chlorine atoms have fewer electron energy levels/shells
- chlorine atoms form stronger bonds
- Cl–Cl bond stronger than Br–Br

- C–Cl bond stronger than C–Br

Energies required
- more energy required to break bonds with chlorine
- more energy given out when making bonds with chlorine
- overall energy change depends on sizes of energy changes

Conclusions
- if C−Cl bond changes less, then less exothermic
- if C−Cl bond changes more, then more exothermic
- can't tell how overall energy change will differ as do not know which changes more.

6

[14]

Q9.

(a) (i) high temperature

allow heating / hot / 250-900 °C

1

catalyst or steam

allow named catalyst eg zeolite, Al_2O_3, silica, ceramic

allow in the absence of air / oxygen

1

ignore any references to pressure

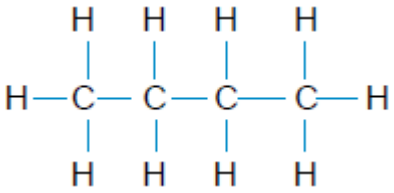
(ii) colourless

allow decolourised

ignore clear / discoloured

1

(iii)



1

(b) (i) 20.3(0) (kJ)

*if answer incorrect allow **1** mark for 24.36/1.2*

2

(ii) use a lid

allow insulate beaker or use draught shield

1

reduce energy / heat loss

ignore references to thermometer or repeats or distance of flame or loss of water vapour

allow stir (1) to distribute energy / heat (1)

allow use a metal can (1) as it's a better conductor (1)

1

(iii) carbon/soot

ignore tar, smoke

1

(produced by) incomplete combustion

allow from a limited supply of oxygen/air

1

(iv) hexane gives out the greatest energy (per 1.0 g)

ignore more energy

1

hexane produces the least smoke / carbon / soot

allow has the cleanest flame

ignore less smoke / carbon / soot

1

(c) Marks awarded for this answer will be determined by the Quality of Written Communication (QWC) as well as the standard of the scientific response. Examiners should also apply a 'best-fit' approach to the marking.

Level 3 (5 – 6 marks):
Descriptions of advantages **and** disadvantages that are linked to their own knowledge.

Level 2 (3 – 4 marks):
Descriptions of an advantage **and** a disadvantage with some use of their knowledge to add value.

Level 1 (1 – 2 marks):
Statements made from the information that indicate whether at least one statement is an advantage **or** a disadvantage
or a linked advantage or disadvantage

0 marks:
No relevant content

Examples of the added value statements and links made in the response could include:
Note that link words are in bold; links can be either way round.
Accept reverse arguments and ignore cost throughout.

Advantages of using hydrogen:
- Combustion only produces water **so** causes no pollution
- Combustion does not produce carbon dioxide **so** this does not contribute to global warming or climate change
- Combustion does not produce sulfur dioxide **so** this does not contribute to acid rain
- Incomplete combustion of petrol produces carbon monoxide **that is** toxic
- Incomplete combustion of petrol produces particulates **that** contribute to global dimming
- Petrol comes from a non-renewable resource **but** there are renewable/other methods of producing hydrogen
- Hydrogen releases more energy **so** less fuel needed or more efficient

Disadvantages of using hydrogen:
- Hydrogen is a gas **so** is difficult to store or transfer to vehicles
- Hydrogen gas is very flammable **so** leaks cause a greater risk of explosion
- Most hydrogen is produced from fossil fuels **which** are running out

- Cannot be used in existing car engines **so** modification / development or replacement is needed
- Lack of filling stations **so** difficult to refuel your vehicle

6

[18]

Q10.

(a) (i) 5.75 **or** 5.8

*correct answer with or without working gains **2** marks*

*correct working showing addition of any four results and division by 4 gains **1** mark*

OR

*6(.04) for **1** mark*

2

(ii) use a polystyrene cup **or** lid

accept insulate the beaker

1

to prevent energy/heat gain

accept to prevent energy/heat transfer

*do **not** accept energy/heat loss*

OR

use a digital thermometer

allow use a data logger

easier to read (to 0.1°C)

1

(b) (as mass increases) the final temperature increases

1

then stays constant

1

correct reference to a value above 8 g up to and including 10 g as mass when the trend changes

1

[7]

Q11.

(a) endothermic

1

(b) 82 (%)

*correct answer with working gains **3** marks*

*if 17 or 34 not shown in working **max 2** marks*

accept 82.4

accept 82.35 to full calculator display (82.35294...) correctly rounded to at least 2 sf

if no answer or incorrect answer, then
*(M_r =) 17 gains **1** mark **or***
*14/17 gains **2** marks*
OR
*($2M_r$ =) 34 gains **1** mark **or***
*28/34 gains **2** marks*
OR
*14/their M_r shown gains **1** mark **or***
*correct calculation of 14/their M_r gains **2** marks*

3

(c) (i) 7 / seven

1

(ii) $H^+ + OH^- \rightarrow H_2O$

1

(iii) ammonium chloride

allow NH_4Cl

1

ignore an incorrect formula

(d) Marks awarded for this answer will be determined by the Quality of Written Communication (QWC) as well as the standard of the scientific response. Examiners should also apply a 'best-fit' approach to the marking.

Level 3 (5 – 6 marks):
Suggestion with reasons from all three graphs, and linking of ideas which may explain a compromise.

Level 2 (3 – 4 marks):
Suggestion with reasons referring to more than one graph.

Level 1 (1 – 2 marks):
Suggestion with a reference to a graph.

0 marks:
No relevant content.

Examples of chemistry points made in response:
A reasonable suggested amount of fertiliser would be in the region of 200 kg (per ha).
Accept any suggestion from about 180 kg (per ha) to 500 kg (per ha).

Yield:
- Using fertiliser improves yield.
- Yield improved most up to about 200 kg (per ha) of fertiliser.
- Yield only increased slightly above about 200 kg (per ha).

Profit:
- About 200 kg of fertiliser gives the most profit.
- Above about 200 kg (per ha) of fertiliser profit declines.

Run off:

- Run off is at low levels until about 300 kg (per ha) of fertiliser.
- Above about 300 kg (per ha) of fertiliser, run off increases.

Examples of linking of ideas:
- Overall 200 kg gives high crop yield and most profit.
- In conclusion 200 kg gives high crop yield and low run off.
- 200 kg gives most profit and low run off.

Examples of compromise:
- Profits go down after about 200 kg (per ha) of fertiliser because cost of fertiliser is not covered by increased yield.
- 200 kg gives the highest profit although it is not the highest yield.
- 500 kg gives the best yield but has the most runoff.

6

[13]

Q12.

(a) water / H_2O

allow steam or hydrogen oxide

1

(b) (i) A

1

(ii) exothermic

1

products (energy) lower than reactants (energy)

1

(iii) 1860 (kJ)

1

(c) (i) 22.5

1

38.7

1

16.2

allow ecf for correct subtraction

1

(ii) 50 (g)

1

(iii) 20.1 (kJ)

allow propanol

ignore 3

1

(iv) as the number of carbon atoms (in one molecule of alcohol) increases the heat energy given out increases (when the alcohol is burned)

1

(v) any **two** from:

- no lid
- no insulation
- no draught shield

Allow heat / energy loss to surroundings for any one of these marks

- incomplete combustion
- inaccurate measurement
- no repeats (to calculate a mean)

2

(iv) -O-H

1

[14]

Q13.

(a) $CH_4 + 2O_2 \rightarrow CO_2 + 2H_2O$

allow multiples

1

(b) 3444 J

if answer incorrect:

one mark for temperature increase = 16.4 °C

one mark for mass of water = 50 g

ecf for one incorrect value gains two marks for correct calculation

no ecf for two incorrect values

3

(c) (i) 1276 (kJ per mole)

ignore + or -

if answer incorrect:

[(5 × 413) + 347 + 358 + 467] + [(3 × 495)] = 4722 (1 mark)

[(4 × 799) + (6 × 467)] = 5998 (1 mark)

correct subtraction of calculated energy values (1 mark)

3

(ii) because energy released when bonds form is greater than energy used when bonds broken

allow converse

if no mark awarded allow one mark for energy is used to break bonds

or

one mark for energy is released when bonds form

2

(iii) products line lower than reactants

1

activation energy labelled

1

overall energy change labelled

1

[12]

Q14.

(a) (i) the products are at a lower energy level than the reactants

accept products have less energy / less energy at the end than the beginning

1

(ii) because a catalyst provides an alternative / different pathway / mechanism / reaction route

accept adsorption or 'increases concentration at the surface'

ignore absorption

1

(that has) lower activation energy

allow weakens bonds

allow idea of increased successful collisions.

DO NOT ALLOW answers stating catalysts provide energy for M1 and M2

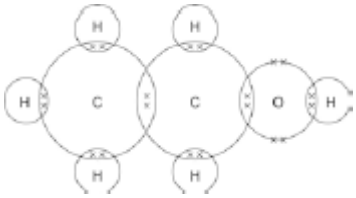
1

(b) one pair of electrons in each overlap (8 pairs in total)

allow any combination of dots, crosses or other symbols

1

the rest of the diagram correct with four non-bonding electrons on the oxygen giving a total of eight electrons in oxygen outer energy level.



*gains **2** marks*

1

(c) (i) ±3024 (J)

*correct answer with or without working gains **3** marks*

*if the answer is incorrect, award up to **2** marks for the following steps:*

- *ΔT = 14.4(°C)*
- *50 x 4.2 x 14.4*

allow ecf for incorrect ΔT

3

(ii) 0.015(2173913)

*correct answer with or without working gains **3** marks*

if answer is incorrect, allow 1 mark each for any of the following steps up to a max of 2.

- *0.70g*

- *M_r of ethanol = 46*
- *0.70 / 46*

allow ecf in final answer for arithmetical errors

3

(iii) ±198 720(J / mole)

c(i) ÷ c(ii)

*allow ecf from **(c)(i)** and **(c)(ii)***

0.015 gives 201600

0.0152 gives 198947

0.01522 gives 198686

1

(d) (as the molecules get bigger **or** the number of carbon atoms increases) the intermolecular forces

allow intermolecular bonds

1

(intermolecular forces) increase

allow more / stronger (intermolecular forces)

1

and therefore require more (heat) energy to overcome

*breaking covalent bonds or unspecified bonds max **1** mark (M3)*

1

[15]

Q15.

(a) 31

1

(b) (i) any **two** from:

- incorrect reading of thermometer / temperature
- incorrect measurement of volume of acid
- incorrect measurement of volume of alkali (burette).

2

(ii) glass is a (heat) conductor **or** polystyrene is a (heat) insulator

*answer needs to convey idea that heat lost using glass **or** not lost using polystyrene*

accept answers based on greater thermal capacity of glass (such as "glass absorbs more heat than polystyrene")

1

(c) (i) temperature increases

1

(ii) no reaction takes place **or** all acid used up **or** potassium hydroxide in excess

1

cool / colder potassium hydroxide absorbs energy **or** lowers temperature

ignore idea of heat energy being lost to surroundings

1

(iii) take more readings

ignore just "repeat"

1

around the turning point **or** between 20 cm^3 and 32 cm^3

accept smaller ranges as long as no lower than 20 cm^3 and no higher than 32 cm^3

1

(d) 1.61 **or** 1.6(12903)

*correct answer with or without working scores **3***

*if answer incorrect, allow a maximum of **two** from:*

*moles nitric acid = (2 × 25 / 1000) = 0.05 for **1** mark*

*moles KOH = (moles nitric acid) = 0.05 for **1** mark*

concentration KOH = 0.05 / 0.031

answer must be correctly rounded (1.62 is incorrect)

3

(e) same amount of energy given out

1

which is used to heat a smaller total volume **or** mixture has lower thermal capacity

or

number of moles reacting is the same

but the total volume / thermal capacity is less

*if no other marks awarded award **1** mark for idea of reacting faster*

1

[14]

Q16.

(a) circle round any one (or more) of the covalent bonds

any correct indication of the bond − the line between letters

1

(b) Methane contains atoms of two elements, combined chemically

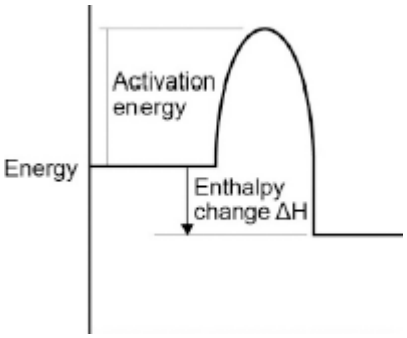
1

(c) (i) activation energy labelled from level of reagents to highest point of curve

ignore arrowheads

1

enthalpy change labelled from reagents to products



*arrowhead **must** go from reagents to products only*

1

(ii) $2\ O_2$

1

$2\ H_2O$

*if not fully correct, award **1** mark for all formulae correct.*

ignore state symbols

1

(iii) carbon monoxide is made

1

this combines with the blood / haemoglobin **or** prevents oxygen being carried in the blood / round body **or** kills you **or** is toxic **or** poisonous

dependent on first marking point

1

(iv) energy is taken in / required to break bonds

accept bond breaking is endothermic

1

energy is given out when bonds are made

accept bond making is exothermic

1

the energy given out is greater than the energy taken in

this mark only awarded if both of previous marks awarded

1

(d) (i) energy to break bonds = 1895

calculation with no explanation max = 2

1

energy from making bonds = 1998

1

1895 − 1998 (= −103)
or
energy to break bonds = 656
energy from making bonds = 759
656 − 759 (= −103)

allow:

bonds broken − bonds made =

413 + 243 − 327 − 432 = -103 for 3 marks.

1

(ii) The C — Br bond is weaker than the C — Cl bond

1

[15]

Q17.

(a) any **one** from:

- solution becomes colourless or colour fades
- zinc becomes bronze / copper coloured
  allow copper (forms) or a solid (forms)
- zinc gets smaller
  allow zinc dissolves
- bubbles or fizzing.
  ignore precipitate

1

(b) improvement:
use a plastic / polystyrene cup or add a lid
accept use lagging / insulation

1

reason - must be linked
reduce / stop heat loss
OR
improvement:

use a digital thermometer
allow use a data logger

reason - must be linked

more accurate or easy to read or stores data
allow more precise or more sensitive
ignore more reliable
ignore improvements to method, eg take more readings

1

(c) Marks awarded for this answer will be determined by the Quality of Written Communication (QWC) as well as the standard of the scientific response. Examiners should also refer to the information in the Marking Guidance and apply a 'best–fit' approach to the marking.

0 marks
No relevant content

Level 1 (1−2 marks)
There is a statement about the results.

Level 2 (3−4 marks)
There are statements about the results. These statements may be linked or may include data.

Level 3 (5−6 marks)
There are statements about the results with at least one link and an attempt at an explanation.

Examples of chemistry points made in the response:

Description:

Statements

Concentration of copper sulfate increases

Temperature change increases

There is an anomalous result

The temperature change levels off

Reaction is exothermic

Linked Statements

Temperature change increases as concentration of copper sulfate increases

The temperature change increases, and then remains constant

After experiment 7 the temperature change remains constant

Statements including data

The trend changes at experiment 7

Experiment 3 is anomalous

Attempted Explanation

Temperature change increases because rate increases

Temperature change levels off because the reaction is complete

Explanation

As more copper sulfate reacts, more heat energy is given off

Once copper sulfate is in excess, no further heat energy produced

6

[9]

Q18.

(a) (i) 11

1

(ii) 4620 (J)

*correct answer gains **2** marks with or without working*

*allow 4.62kJ for **2** marks*

if answer is incorrect:

*100 × 4.2 × 11 gains **1** mark*

or

*100 × 4.2 × (their temp. rise) gains **1** mark*

or

*100 × 4.2 × (their temp. rise) correctly calculated gains **2** marks*

2

(b) the temperature increases

allow gets hotter

allow heat / energy is given off

1

(c) (i) (energy of) products lower than (energy of) reactants

allow converse

allow arrow C points downwards

1

(ii) A

1

[6]

Q19.

(a) (i) nothing can enter **and** nothing can leave the reaction

allow sealed reaction vessel

1

(ii) forward and backward reactions have same rate

1

so there is no (overall) change in quantities of reactants and products

allow concentrations of reactants and products

1

(b) (i) natural gas

allow methane / CH_4

allow fossil fuels / hydrocarbons

allow water

1

(ii) provides an alternative reaction pathway

1

which has a lower activation energy

ignore references to collisions

1

(iii) the amount (of ammonia) increases

allow yield increases

1

the equilibrium moves to the side (of the equation) with fewer (gaseous) molecules / moles

allow it favours the forward reaction

1

(c) (i) vertical arrow from reactants to maximum

1

(ii) (energy of) products higher than (energy of) reactants

allow converse

1

(iii) amount of hydrogen iodide decreases

1

equilibrium moves in the direction of the endothermic reaction

allow it favours the forward reaction

1

[12]

Q20.

(a) (i) any **one** from:

- incorrect measurement of temperature or volume
- incorrect recording of temperature
- failure to stir
- heat loss

ignore faulty equipment

1

(ii) 32 - 33

1

(iii) 55

1

(iv) 20

1

(v) 4620

*allow 4.62 kJ for **2 marks***

1

J / joules

allow kJ if evidence of dividing by 1000

mark independently, but if a numerical answer has been divided by 1000 must be kJ.

allow ecf from their answers to (iii) and (iv)

1

(b) twice as much energy released

1

but twice as much water to heat

*allow more energy released but more water to heat for **2 marks***

*if no other mark awarded, allow twice the amount of hydrochloric acid used for **1 mark***

1

[8]

Q21.

(a) (i) covalent

1

(ii) increases the rate of reaction

1

(b) (i) the reaction is reversible

1

(ii) at lower pressure the molecules will be further apart

1

so there will be fewer collisions <u>per unit time</u>

accept frequency of collisions lower

1

(iii) as the temperature increases, the yield of the reaction increases

1

(iv) 2 molecules / volumes become 4 **or** more molecules / volumes **of** product than reactant

1

(c) Marks awarded for this answer will be determined by the Quality of Communication (QoC) as well as the standard of the scientific response. Examiners should also refer to the information on page 5, and apply a 'best-fit' approach to the marking.

0 marks
No relevant content

Level 1 (1 – 2 marks)
Candidate has written about some basic points from the table but has not added any extra knowledge. Candidate may have included advantages **or** disadvantages.

Level 2 (3 – 4 marks)
Candidate has attempted an evaluation using points from the table and their own knowledge. Candidate has included advantages **and** disadvantages.

Level 3 (5 – 6 marks)
Candidate has given an evaluation that includes both advantages and disadvantages. Candidate has clearly linked points from the table with their own knowledge and uses appropriate scientific terminology.

examples of the points made in the response

Advantages of using hydrogen:

- its combustion only produces water
- combustion of hydrogen does not produce carbon dioxide **or** does not contribute to climate change
- petrol requires much more oxygen to burn so partial combustion is possible producing carbon monoxide
- combustion of hydrogen does not produce any particulates **or** does not contribute to global dimming
- petrol comes from a non-renewable source **or** there are renewable ways of producing hydrogen, eg electrolysis of water.

Disadvantages of using hydrogen:

- hydrogen has to be stored at high pressure **or** risk of explosion or larger volume needed for storage.
- much less energy produced from the combustion of hydrogen **or** need to refuel more often
- most methods of producing hydrogen need fossil fuels.

6

[13]

Q22.

(a) products are at a lower energy level than reactants

if candidate has drawn a profile for an endothermic reaction penalise first marking point only

1

activation energy correctly drawn and labelled

1

ΔH correctly labelled

1

(b) (i) –93 (kJ per mole)

*correct answer with or without working gains **3** marks*

*allow **2** marks for +93 kJ per mole*

*if any other answer is seen award up to **2** marks for any two of the steps below:*

*bonds broken (614 + 193) = 807 (kJ) **or** (614 + 193 + (4 × 413)) = 2459(kJ)*

*bonds formed (348 + 276 + 276) = 900(kJ) **or** 348 + (2 × 276) + (4 × 413) = 2552(kJ)*

bonds broken – bonds formed

allow ecf for arithmetical errors

3

(ii) more energy is released when the bonds (in the products) are formed

1

than is needed to break the bonds (in the reactants)

*if no other marks gained, allow **1** mark for energy released for bond making **and** energy used for bond breaking*

1

[8]

Q23.

(a) the forward and backward reactions occur

allow reversible

1

at (exactly) the same rate

1

in a closed system

allow therefore the concentrations / amounts of the reactants and products remain the same

1

(b) (i) increasing the temperature would lower the yield of ethanol **or** the (position of) equilibrium moves to the left

*if student has stated that increasing the temperature increases the yield then award **0** marks*

1

since the backwards reaction is endothermic **or** the forward reaction is exothermic

1

(ii) increasing the pressure would increase the yield of ethanol **or** the (position of) equilibrium moves to the right

*if student has stated that increasing the pressure decreases the yield then award **0** marks*

1

because the position (of equilibrium) moves in the direction of the lower number of moles (of gas)

2 (moles / molecules / volumes / particles) on lhs / 1 (mole / molecule / volume / particle) on rhs

1

(c) (a catalyst) provides an alternative pathway

1

with lower activation energy

or

(a catalyst) lowers the activation energy (1)

so less energy is needed to react **or** more particles react (1)

1

[9]

Q24.

(a) any **three** from:

- concentration of (salt) solution

- volume of (salt) solution
  ignore amount of solution
- **initial** temperature (of the solution)
  ignore room temperature
- surface area / form of metal
- moles of metal
  allow mass / amount
  ignore time
  ignore size of tube

3

(b) 20

1

32

1

12
allow ecf

1

(c) (i) four bars of correct height
tolerance is + / - half square
*3 correct for **1** mark*

2

bars labelled

1

(ii) *one variable* is non-continuous / categoric
accept qualitative or discrete
accept no values between the metals

1

(iii) magnesium

1

because biggest temperature change
accept gives out most energy
ignore rate of reaction
dependent on first mark

1

(iv) does not react / silver cannot displace copper

1

because silver not more reactive (than copper) **or** silver below copper in reactivity series
*do **not** accept silver is less reactive than copper sulfate*

1

(v) replace the copper sulfate
could be implied

1

with any compound of a named metal less reactive than copper

allow students to score even if use an insoluble salt

1

[16]

Q25.

(a) (i) ions cannot move

allow only conducts as a liquid

1

(ii) chlorine

1

(iii) they are positively / oppositely charged

or

they are attracted

1

(iv) 2

1

(b) (i) any **one** from:

- not all the magnesium was collected

  allow some magnesium was lost
- *used less time **or** lower current **or** different battery / power pack **or** different balance **or** lower voltage*
- error in reading balance
- error in recording result

1

(ii) 1.11

*correct answer with or without working gains **2** marks.*

*if answer incorrect, allow **1** mark for 0.99*

***or** for 1.13 + 1.11 + 1.09*

2

(c) (i) *25 – 25.3*

*correct answer with or without working gains **2** marks.*

*If answer incorrect, allow **1** mark for 24 / 95*

2

(ii) 71

1

(d) (i) reversible reaction

1

(ii) decreases

1

[12]

Q26.

(a) (i) so ions can move (and carry charge)

accept so current can flow
allow so it can conduct (electricity)
allow so charged particles can move
*do **not** accept so electrons can move*

1

(ii) because zinc ions gain electrons

accept because zinc ions are reduced

1

2 (electrons)

1

zinc is formed

*accept correct half equation for **3** marks*
if no mark gained allow
*positive ions go to negative electrode **or***
*opposites attract **or***
*reduction (of zinc) **or***
*(zinc) gains electrons for **1** mark*

1

(iii) **2** Cl^- ⟶ Cl_2 + **2** e^-

must be completely correct

1

(b) (i) because the magnesium is *a gas*

allow magnesium goes from solid to gas

1

(ii) (a reaction which) takes in energy (from the surroundings)

accept more energy needed to break bonds than released by forming bonds
accept correct reference to energy level diagram
allow (a reaction which) takes in heat (from the surroundings)

1

(iii) (M_r MgO =) 40

accept (2 M_r MgO =) 80

1

1.2 / 24 (x40) **or** 0.05 (x40)

or

40 / 24 (x1.2) **or** 1.67 (x1.2)

allow ecf from step 1

1

2(.0)

allow ecf carried through from step 1

*correct answer with or without working gains **3** marks*

1

(iv) 75(%)

1

(v) any **one** from:

- the reaction is reversible

  accept incomplete reaction

  ignore equilibrium not reached
- *some lost / escaped / released (when* separated)
- some of the reactant may react in different ways from the expected reaction
- *impure reactant(s)*

  ignore measurement and calculation errors

1

[12]

Q27.

(a) electrical

1

(b) (i) 900

accept any answer between 840 and 960

1

(ii) any **one** from:

- little demand
- few hydrogen cars
- *changeover from petrol to hydrogen will take time*

  allow answers in terms of petrol

1

(c) X on rising section of *line*

1

[4]

Q28.

(a) $2NH_3$

*allow NH_3 with incorrect or missing balancing for **1** mark*

allow multiples

2

(b) (i) 200

1

(ii) rate of reaction (too) slow

allow converse

ignore references to yield / cost

1

(iii) 400

1

(iv) lower yield

allow converse
accept shifts equilibrium to left
allow favours the backward reaction
allow favours side with more (gaseous) molecules
allow lower rate

1

(c) (gases) cooled

it = ammonia

1

ammonia liquefied

accept ammonia condensed
*accept ammonia cooled below boiling point for **2** marks*

1

[8]

Q29.

(a) electrical

1

(b) using hydrogen saves petrol / diesel / *crude oil*

allow crude oil is non-renewable
ignore hydrogen is renewable

1

using hydrogen (in fuel cells) does not cause pollution

accept no carbon dioxide produced
allow less carbon dioxide produced
allow hydrogen produces <u>only</u> water

1

(c) (i) (–)486

*correct answer with or without working gains **3** marks*
if answer is incorrect:
*(2 × 436) + 498 **or** 1370 gains **1** mark*
*4 × 464 **or** 1856 gains **1** mark*
*correct subtraction of ecf gains **1** mark*

3

(ii) products lower than reactants

1

reaction curve correctly drawn

1

activation energy labelled

1

[9]

Q30.

(a) exothermic

1

(b) ‘Should people use kelp instead of oil as an energy source?’

1

‘Will kelp be more popular than coal in the next 10 years?’

1

(c) (i) any **four** from:

*If atom or ion omitted = max **3***

sharing / covalent / metallic
*= max **3***

ignore reference to full outer shells

- potassium (atom) loses (an electron) and iodine (atom) gains (an electron)
- 1 electron
- iodide (ion) has negative charge
  allow iodine ion
- potassium (ion) has positive charge
- electrostatic attraction **or** ionic bonding
  *accept stable (structure) **or** noble gas (structure)*

4

(ii) because a solid is formed (from two aqueous solutions)

1

(iii) filtering **or** centrifuging **or** decanting

1

[9]

Q31.

(a) (i) to increase the rate of reaction

1

(ii) H_2SO_4 on the left hand side

1

H_2O on right hand side

1

(iii) filtration

*allow centrifuging **or** decanting*

ignore evaporation if after filtration

1

(iv) crystallisation

ignore reference to filtration unless given as an alternative

or

evaporation / heating / boiling / cooling

1

(v) any **one** from:

- because of an incomplete reaction
  accept not all acid reacted
  accept impure reactants
  accept unexpected reaction
  ignore reversible reaction
- because some (copper sulfate) lost on filtering **or** when poured into evaporating basin **or** boiled over **or** left in apparatus
  must specify when lost
  *accept some (copper sulfate **or** acid) spilt*
- weighing error (of copper sulfate)

1

(b) (i) reversible (reaction)

1

(ii) 300(J)

allow the same

1

(energy) given out / released

accept exothermic / –
*ignore increasing **or** decreasing energy*

1

(c)

$\frac{3.81}{63.5}$ $\frac{0.28}{14}$

***1** mark for dividing mass by A_r (max **2** if A_r divided by mass)*

1

= 0.06 = 0.02

***1** mark for correct proportions*

1

3 1

***1** mark for correct whole number ratio (allow multiples). Can be awarded from formula*

1

Cu_3N

ecf** allowed from **step 2 to step 3** and **step 3 to step 4** if sensible attempt at step **1

*correct formula gains **1** mark*

1

[13]

Q32.

(a) Will kelp last longer than coal as an energy source?

1

(b) any **two** from:

- cannot be determined by experiment

  allow can't predict how long kelp / coal will last

  allow more testing needed

- based on opinion

- ethical **or** environmental **or** economic reason

  allow could damage ecosystem allow reference to cost

2

(c) (i) 7

1

(ii) sodium (atom) loses (electron) **and** iodine (atom) gains (an electron)

*reference to incorrect bonding **or** incorrectly named particle = max **2***

any or all marks can be obtained from a labelled diagram

ignore inner shell electrons if shown

1

1 electron

1

(electrostatic) attraction **or** forms ionic bond(s)

1

(iii) ions can move (in the solution)

1

(iv) $2\,I^- \rightarrow \mathbf{I_2} + \mathbf{2}\,e^-$

1

(v) hydrogen is formed

1

because sodium is more reactive (than hydrogen)

1

[11]

Q33.

(a) eg plastic (beaker) / insulation / lid / cover **or** any mention of enclosed

any sensible modification to reduce heat loss

ignore prevent draughts

ignore references to gas loss

ignore bomb calorimeter

1

(b) all the substances react **or** all (the substances) react fully / completely **or** heat evolved quickly **or** distribute heat

'so they react' is insufficient for the mark

accept increase chances of (successful) collisions / collision rate increase

*do **not** accept rate of reaction increase / make reaction faster*

1

(c) experiment 2 **and**
different / higher / initial / starting temperature

*accept experiment 2 **and** the room is hotter / at higher temperature*

*do **not** accept temperature change / results higher*

1

(d) temperature change does not fit pattern

*accept anomalous / odd **or** it is the lowest **or** it is lower than the others **or** it is different to the others*

'results are different' is insufficient

1

(e) 7 / 7.0

1

(f) (100 × 4.2 × 7) = 2940

ecf from (e)

1

(g) diagram A **and**
reaction exothermic / heat evolved / Δ H is negative / temperature rises

accept energy is lost (to the surroundings)

accept energy of products lower than reactants

allow arrow goes downwards

1

[7]

Q34.

(a) heat / energy

1

given out / transfers to surroundings

the mark for given out / transfers to cannot be awarded without heat / energy

allow given off

1

(b) (i) decreases

1

increases

1

(ii) it gives the particles more energy

1

it makes the particles move faster

1

[6]

Q35.

(a) (i) energy / heat of products less than energy of reactants

allow converse

allow products are lower than reactants

allow more energy / heat given out than taken in

allow methanol is lower

allow energy / heat is given out / lost

allow ΔH is negative

1

(ii) lowers / less activation energy

allow lowers energy needed for reaction
***or** it lowers the peak/ maximum*

*do **not** allow just 'lowers the energy'*

1

(b) (i) (8 × 435) + 497 = 3977

accept: bonds broken: (2 × 435) + 497 = 1367

1

(6 × 435) + (2 × 336) + (2 × 464) = 4210

bonds made: (2 × 336) + (2 × 464) = 1600

1

3977 – 4210 = (–) 233

energy change:

1367 – 1600 = (–) 233

ignore sign

allow ecf

*correct answer (233) = **3** marks with or without working*

1

(ii) energy released forming (new) bonds is greater than energy needed to break (existing) bonds

allow converse

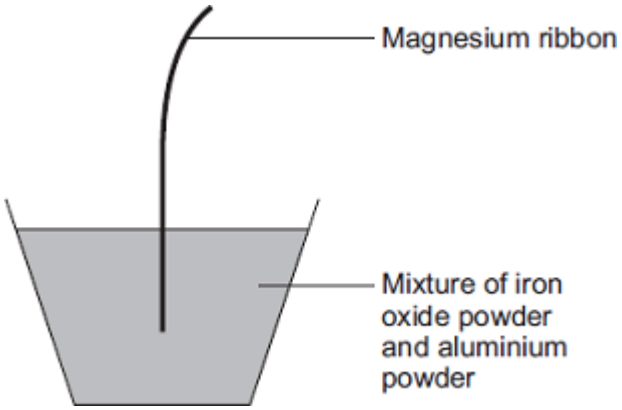
*do **not** accept energy needed to form (new) bonds greater than energy needed to break (existing) bonds*

1

[6]

Q1.

The diagram shows one way of producing iron.



Iron oxide reacts with aluminium to produce iron.

The symbol equation for the reaction is:

$Fe_2O_3 + 2\ Al \longrightarrow 2\ Fe + Al_2O_3$

(a) (i) Complete the word equation for this reaction.

iron oxide + aluminium ⟶ iron + _____

(1)

(ii) The magnesium ribbon is lit to start the reaction.

Why does the burning magnesium ribbon start the reaction?

_____

_____

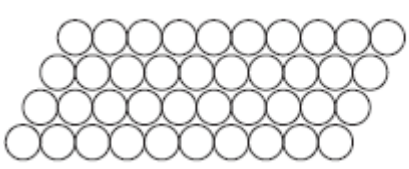
(1)

(b) In industry, iron is produced in the blast furnace when iron oxide is heated with carbon.

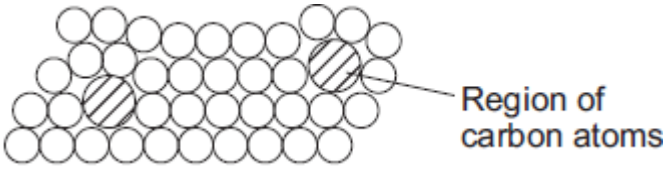
The iron from the blast furnace is called cast iron.

Cast iron contains carbon.

The diagrams show the structure of pure iron and cast iron.



Pure iron



Cast iron

Use the diagrams to help you answer the questions.

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

Pure iron is an element because pure iron

contains only one sort of atom.
is magnetic.
is a metal.

(1)

(ii) Suggest why cast iron is harder than pure iron.

_____

_____

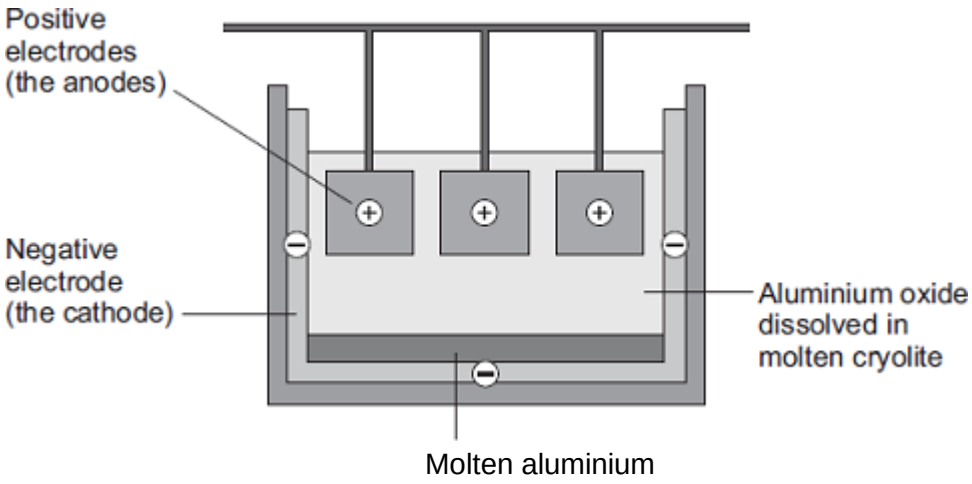
_____

_____

_____

(2)

(c) Aluminium is extracted by electrolysis using the ionic compound aluminium oxide.



(i) Aluminium **cannot** be extracted by heating aluminium oxide with carbon.

Suggest why.

_____

_____

(1)

(ii) Why is aluminium oxide dissolved in molten cryolite?

_____

_____

(1)

(iii) Aluminium metal is produced at the negative electrode (cathode).

Complete the half equation for the process.

Al^{3+} + _____ e^- ⟶ Al

(1)

(iv) Use the half equation to state why Al^{3+} ions are reduced.

_____

_____

(1)

(v) Explain why the positive electrodes (anodes) burn away.

Use your knowledge of the products of electrolysis to help you.

_____

_____

_____

_____

_____

_____

_____

_____

_____

_____

(4)

(Total 13 marks)

Q2.

(a) Which sub-atomic particles are present in the nucleus of an atom?

_____ and _____

(2)

(b) There are two isotopes of the element chlorine:

$^{35}_{17}Cl$ $^{37}_{17}Cl$

Describe, in terms of sub-atomic particles, **one** similarity and **one** difference between atoms of the two isotopes of chlorine.

Similarity _____

_____

Difference _____

_____

(2)

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

(i) The table shows the values of some bond dissociation energies.

Bond	**H—H**	**Cl—Cl**	**H—Cl**
Dissociation energy in kJ per mole	436	242	431

Use the values in the table to calculate the enthalpy change (ΔH) for the reaction.

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

_____

_____

_____

_____

_____

Enthalpy change (ΔH) = _____ kJ per mole

(3)

(ii) Hydrogen also reacts with fluorine.

$H_2(g) + F_2(g) \longrightarrow 2\ HF(g)$ $\Delta H = -538$ kJ per mole

Draw an energy level diagram for this reaction.

Include on your diagram labels to show:

- the reactants and the products
- the overall enthalpy change (ΔH)
- the activation energy.

(3)

(Total 10 marks)

Q3.

When ammonium chloride is dissolved in water, there is a temperature change.

A student investigated how the temperature of water changed when different masses of ammonium chloride were added to the same volume of water.

The water used was at room temperature.

The student's results are shown in the table.

Mass of ammonium chloride in g	Final temperature of solution in °C
10	14.5
20	8.5
25	5.5
30	2.5
35	1.0
40	1.0
45	1.0

(a) (i) Use the correct word from the box to complete the sentence.

endothermic	exothermic	reduction

When ammonium chloride dissolves in water, the change can be

described as _____ .

(1)

(ii) Give a reason for your answer to part **(a) (i)**. Refer to the table of results in your answer.

_____

_____

(1)

(b) The student added the ammonium chloride to water and stirred the mixture.

The water was in a glass beaker.

His teacher said that using a glass beaker could cause inaccurate results.

What could the student have used instead of a glass beaker to improve the accuracy?

Give a reason why this would improve the accuracy of his results.

_____

_____

_____

_____

_____

(2)

(c) The student made sure his investigation was a fair test.

State **two** control variables the student should keep the same.

Give a reason why changing each of these two control variables would affect the temperature change.

Control variable 1 _____

Reason _____

_____

_____

Control variable 2 _____

Reason _____

_____

_____

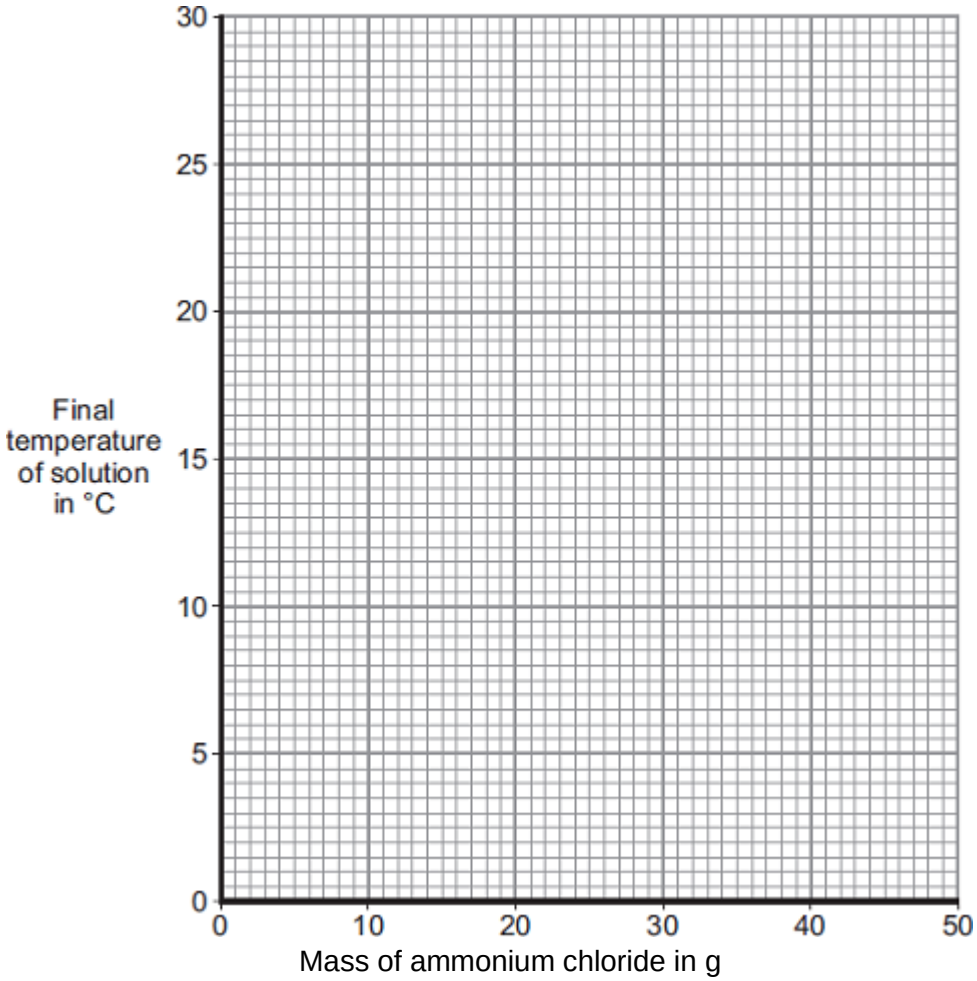
(4)

(d) (i) The student's results table has been repeated below.

Mass of ammonium chloride in g	Final temperature of solution in °C

10	14.5
20	8.5
25	5.5
30	2.5
35	1.0
40	1.0
45	1.0

Plot the results on the grid.



(2)

(ii) Complete the graph by drawing two straight lines of best fit through the points.

(2)

(iii) Use the graph to estimate the temperature of the room.

Show your working on the graph.

Temperature of room = _____ °C

(2)

(e) Explain why the final temperature was the same for all masses of 35 g and greater.

_____

_____

_____

_____

(2)

(f) A second student also did one of the experiments.

This student recorded a final temperature of 14.5 °C.

Both students dissolved 20 g of ammonium chloride in water.

Use the graph to explain the difference in the two final temperatures.

_____

_____

_____

_____

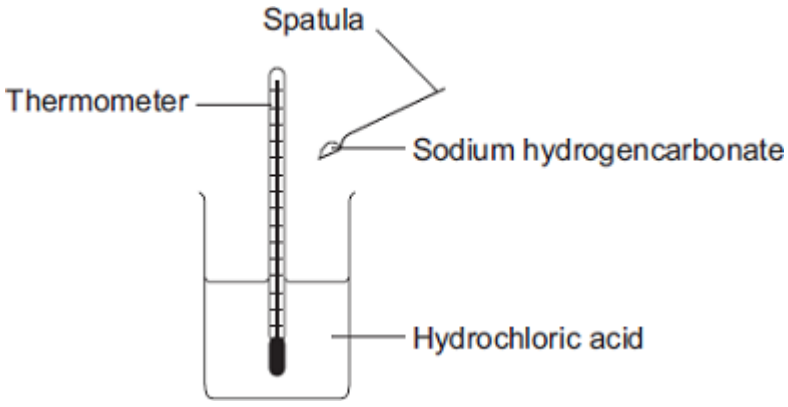
_____

(2)

(Total 18 marks)

Q4.

(a) Some students did an experiment to find the temperature change when hydrochloric acid reacts with sodium hydrogencarbonate.



The results are in the table.

Number of spatula	Start	Final	Change in

measures of sodium hydrogencarbonate	temperature in °C	temperature in °C	temperature in °C
2	20	16	4
4	20	14	6
6	19	11	8
8	20	10	10
10	19	9	10
12	20	10	10

(i) Describe, as fully as you can, the trends shown in the students' results.

(3)

(ii) State the type of energy transfer for this reaction.

(1)

(b) Sodium hydrogencarbonate is used as baking powder for making cakes.

When the cake mixture is baked the sodium hydrogencarbonate decomposes.

The equation for the reaction is:

$$2\,NaHCO_3(s) \xrightarrow{Heat} Na_2CO_3(s) + H_2O(g) + CO_2(g)$$

(i) The cake mixture rises when baked.

Use the equation to suggest why.

_____

_____

(1)

(ii) The same reaction can be reversed to produce sodium hydrogencarbonate from sodium carbonate.

$$Na_2CO_3 + H_2O + CO_2 \longrightarrow 2NaHCO_3$$

Do the reactants need to be heated?

Give a reason for your answer.

_____

_____

(1)

(c) (i) Calculate the relative formula mass of sodium hydrogencarbonate ($NaHCO_3$).

Relative atomic masses (A_r): H=1; C=12; O=16; Na=23

_____

_____

_____

Relative formula mass (M_r) = _____

(2)

(ii) Calculate the percentage by mass of carbon in sodium hydrogencarbonate.

_____

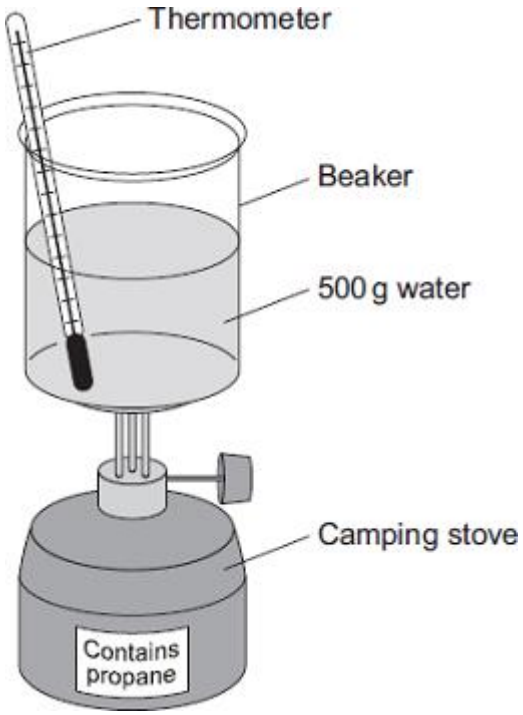
Percentage of carbon = _____ %

(1)

(Total 9 marks)

Q5.

A camping stove uses propane gas.



(a) A student did an experiment to find the energy released when propane is burned.

The student:

- put 500 g water into a beaker
- measured the temperature of the water
- heated the water by burning propane for 1 minute
- measured the temperature of the water again.

The student found the temperature change was 20 °C.

The student can calculate the energy released, in joules (J), using the equation:

energy released (J) = mass of water (g) × 4.2 × temperature change (°C)

(i) Use the student's result to calculate the energy released in joules (J).

Energy released = _____ J

(2)

(ii) State **two** safety precautions that the student should take during the experiment.

1. _____

_____

2. _____

_____

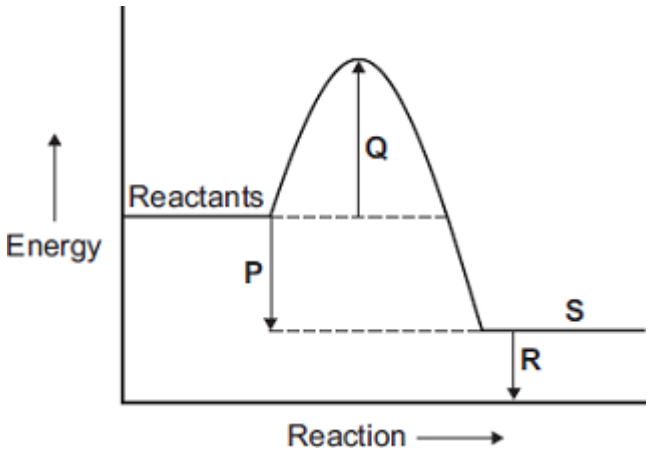
(2)

(iii) Tick (✓) **two** boxes which describe how the student could make his result more accurate.

	Tick (✓)
Stir the water before measuring the temperature.	
Heat the water until it boils.	
Place a lid on the beaker.	
Use a larger beaker for the water.	

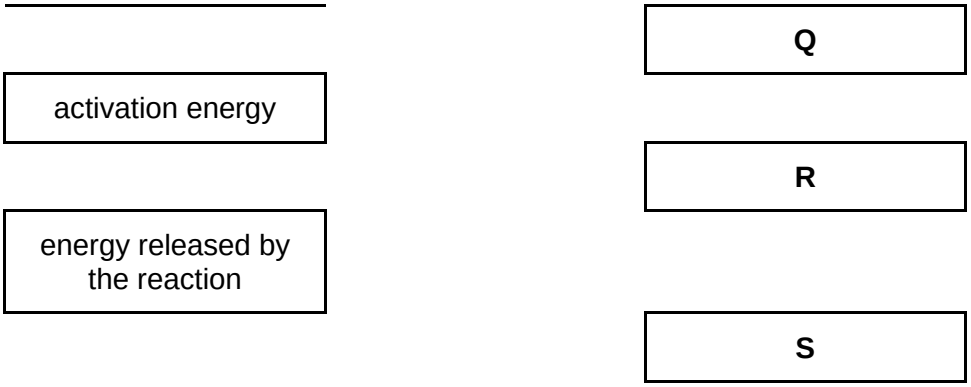
(2)

(b) The change in energy when propane is burned can be shown in an energy level diagram.



Draw **one** line from each description to the correct letter.

Description	**Letter**
	P
products	



(3)

(c) Propane and hydrogen are both used as fuels.

Some information about propane and hydrogen is given in the table.

Fuel	Resource	Products formed when fuel burned
propane	crude oil	carbon dioxide and water
hydrogen	water	water

Use the information in the table to suggest **two** disadvantages that propane has as a fuel compared to hydrogen.

1. _____

_____

2. _____

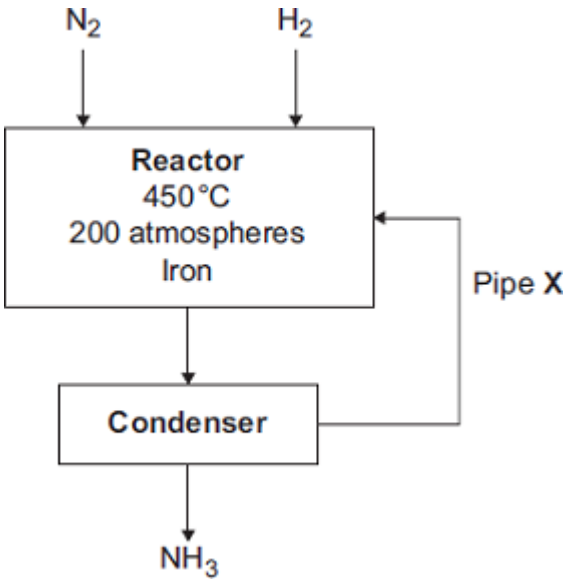
_____

(2)

(Total 11 marks)

Q6.

The flow diagram shows the Haber process. In the Haber process, ammonia (NH_3) is produced from nitrogen (N_2) and hydrogen (H_2).



(a) Which raw material is nitrogen obtained from?

_____

(1)

(b) What is the purpose of Pipe **X**?

_____

_____

_____

_____

(2)

(c) Balance the chemical equation below for the production of ammonia.

N_2 + _____H_2 ⇌ _____NH_3

(1)

(d) A temperature of 450°C is used in the reactor.
The reaction of nitrogen with hydrogen is reversible.
The forward reaction is exothermic.

Explain why a temperature of 450°C is the optimum temperature for the Haber process.

_____

_____

_____

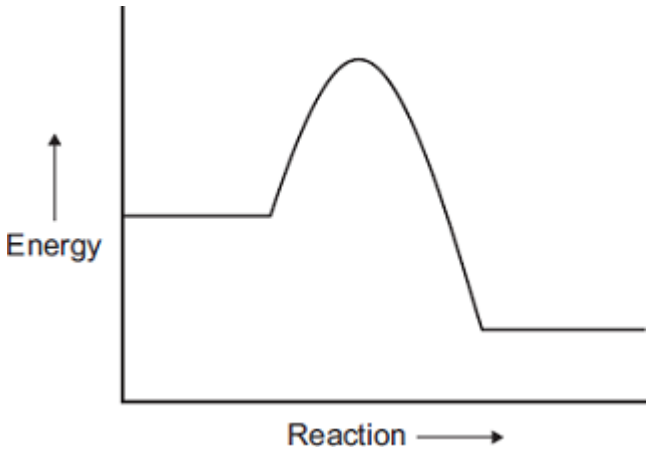
_____

_____

_____

(2)

(e) An energy level diagram for the reaction between nitrogen and hydrogen is shown below.



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

_____

_____

(1)

(ii) In the Haber process iron is used as a catalyst.

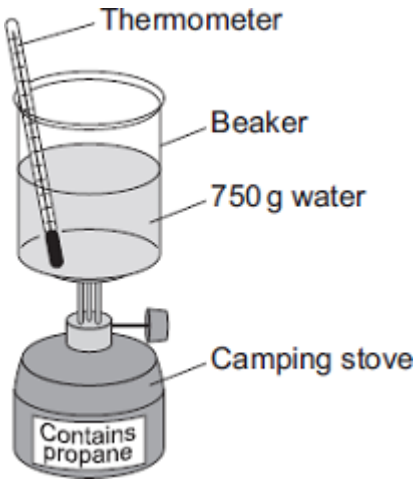
Draw a line on the energy level diagram to show the effect of adding a catalyst.

(1)

(Total 8 marks)

Q7.

A camping stove uses propane gas.



(a) A student did an experiment to find the energy released when propane is burned.

The student:

- put 750 g water into a beaker
- measured the temperature of the water, which was 17 °C
- heated the water by burning propane
- measured the temperature of the water again, which was then 64 °C.

The student calculated the energy released using the equation

$$Q = m \times 4.2 \times \Delta T$$

Where:

Q = energy released (J)

m = mass of water (g)

ΔT = temperature change (°C)

(i) Use the student's results to calculate the energy released in joules (J).

Energy released = _____

(3)

(ii) To find how much propane had been used the student weighed the camping stove before and after the experiment. The mass of the camping stove decreased by 6.0 g.

Using this information and your answer to part (a)(i), calculate the energy in kJ released when 1 mole of propane burns.

(If you have no answer for part (a)(i), assume the energy released during the experiment is 144 000 J. This is not the answer to part (a)(i).)

Relative formula mass (M_r) of propane = 44.

Energy released = _____ kJ

(2)

(iii) Suggest **two** things the student could do to make his results more accurate.

(2)

(iv) The student's method does **not** give accurate results.

However, this method is suitable for comparing the energy released by different fuels.

Suggest why.

(1)

(b) The student used bond energies to calculate the energy released when propane is burned.

The equation for the combustion of propane is:

$$C_3H_8 + 5O_2 \longrightarrow 3CO_2 + 4H_2O$$

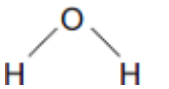
Some bond energies are given in the table

Bond	Bond Energy in kJ per mole
C ═ O	830
O — H	464

The displayed structures of the products are:

carbon dioxide O ═ C ═ O

water



(i) Calculate the energy released by bond making when the products are formed.

Energy released = _____ kJ per mole

(3)

(ii) The energy used for bond breaking of the reactants in the equation is 6481 kJ per mole.

Calculate the overall energy change of this reaction.

Overall energy change = _____ kJ per mole

(1)

(Total 12 marks)

Q8.

Read the information.

> Alumina is a white solid. In 1800, scientists thought that alumina contained an undiscovered metal. We now call this metal aluminium. At that time, scientists could not extract the aluminium from alumina.
>
> In 1825, Christian Oersted, a Danish scientist, did experiments with alumina.
>
> **Step 1** He reacted a mixture of hot alumina and carbon with chlorine to form aluminium chloride. The reaction is very endothermic.
>
> **Step 2** The aluminium chloride was reacted with potassium. He was left with potassium chloride and tiny particles of aluminium metal.
>
> Other scientists were **not** able to obtain the same results using his experiment and his work was not accepted at that time.
>
> In 1827, Friedrich Wöhler, a German chemist, made some changes to Oersted's experiment. He obtained a lump of aluminium. He tested the aluminium and recorded its properties.

(a) Suggest why scientists in 1800 could not extract aluminium from alumina.

(1)

(b) Oersted's experiment in 1825 was **not** thought to be reliable.

Explain why

_____

_____

(1)

(c) Why must the reaction in **Step 1** be heated to make it work?

_____

_____

(1)

(d) Complete the word equation for the reaction in **Step 2**.

aluminium chloride + potassium → _____ + _____

(1)

(e) Suggest how Wöhler was able to prove that he had made a new metal.

_____

_____

_____

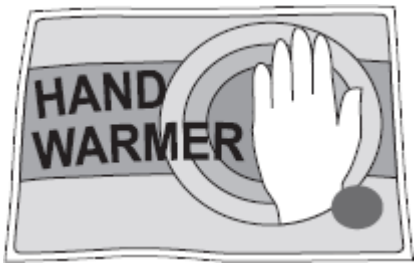
_____

(2)

(Total 6 marks)

Q9.

Hand warmers use chemical reactions.



(a) The table shows temperature changes for chemical reactions **A**, **B** and **C**.

Reaction	Starting temperature in °C	Final temperature in °C	Change in temperature in °C

A	18	25	+ 7
B	17	_____	+ 5
C	18	27	+ 9

What is the final temperature for reaction **B**? Write your answer in the table.

(1)

(b) (i) What name is given to reactions that heat the surroundings?

_____

(1)

(ii) Which reaction, **A**, **B** or **C**, would be best to use in a hand warmer?

Reaction ☐

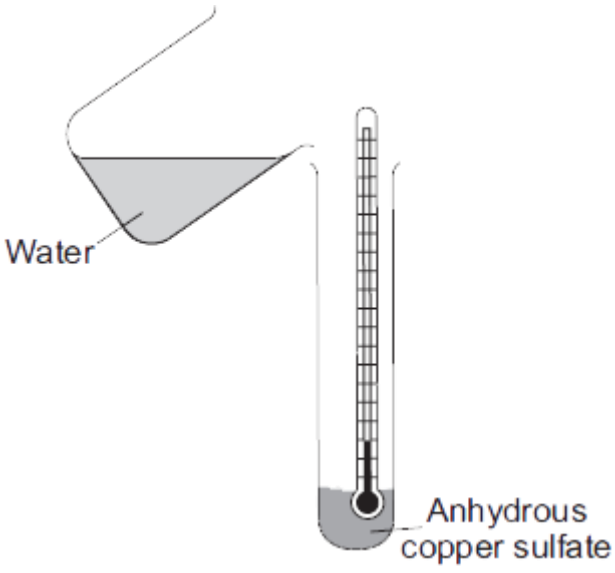
Give a reason why you chose this reaction.

_____

_____

(2)

(c) A student added water to some anhydrous copper sulfate.



The equation for the reaction is shown.

anhydrous copper sulfate + water ⇌ hydrated copper sulfate

$CuSO_4$ + 5 H_2O ⇌ $CuSO_4.5H_2O$

The student measured the temperature before and after the reaction.

(i) The measurements showed that this reaction can be used for a hand warmer.

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

When water is added to anhydrous copper sulfate the temperature

of the mixture

increases.
decreases.
stays the same.

(1)

(ii) Anhydrous copper sulfate is white.

What colour is seen after water is added to the anhydrous copper sulfate?

_____

(1)

(iii) What does the symbol ⇌ mean?

_____

(1)

(iv) The student heated a tube containing hydrated copper sulfate.

Name the solid substance produced.

_____

(1)

(Total 8 marks)

Q10.

The symbol equation for the decomposition of hydrogen peroxide is:

$$2H_2O_2 \rightarrow 2H_2O + O_2$$

(a) This reaction is *exothermic*.

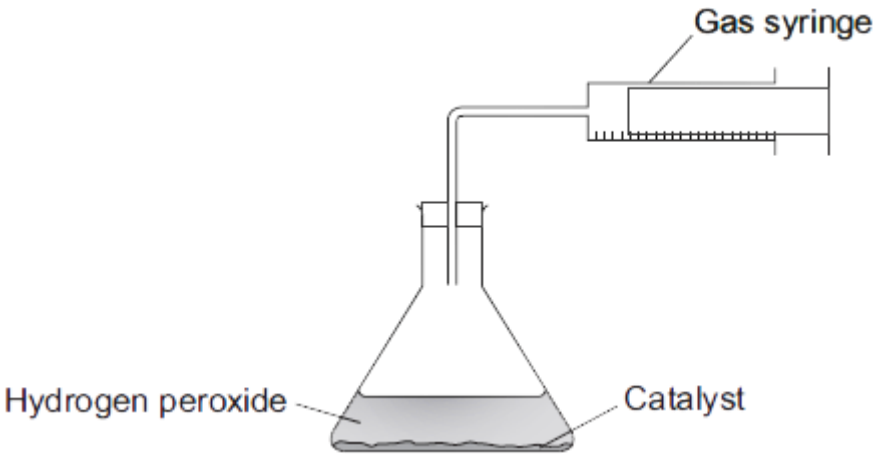
What is an *exothermic* reaction?

_____

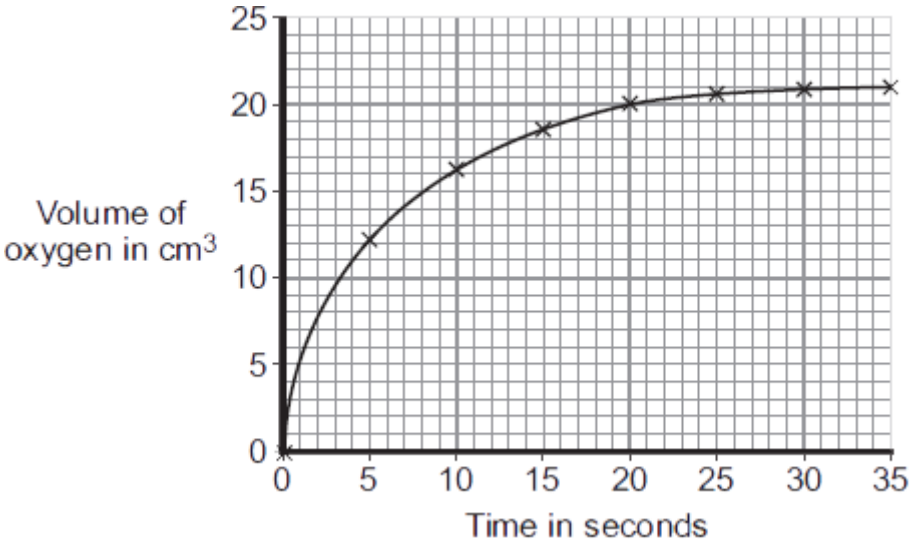
_____

(1)

(b) A student measured the volume of oxygen produced by 50 cm^3 of hydrogen peroxide.



The graph shows the results.



(i) Use the graph to describe the changes in the rate of the reaction from 0 to 35 seconds.

_____

_____

_____

_____

_____

_____

(3)

(ii) What was the total volume of oxygen gas collected?

_____ cm^3

(1)

(iii) The student had calculated that the hydrogen peroxide used should

produce 25 cm^3 of oxygen.

Calculate the percentage yield of oxygen.

_____

_____

_____

Answer = _____ %

(2)

(c) An increase in the temperature of the hydrogen peroxide increases the rate of the reaction.

Use your knowledge of particles to explain why.

_____

_____

_____

_____

_____

_____

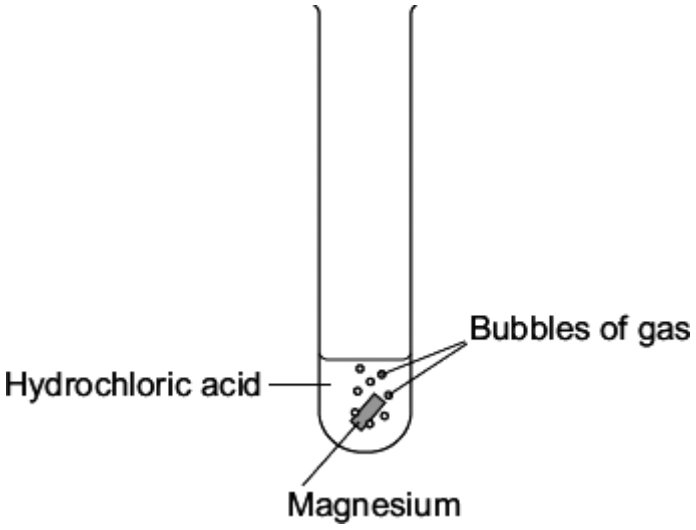
(3)

(Total 10 marks)

Q11.

A student investigated the reaction of magnesium with hydrochloric acid.

(a) A piece of magnesium was dropped into the hydrochloric acid.



Bubbles of gas were produced and the magnesium disappeared.

The reaction is exothermic.

(i) What measurements would the student make to show that the reaction is exothermic?

_____

_____

_____

_____

(2)

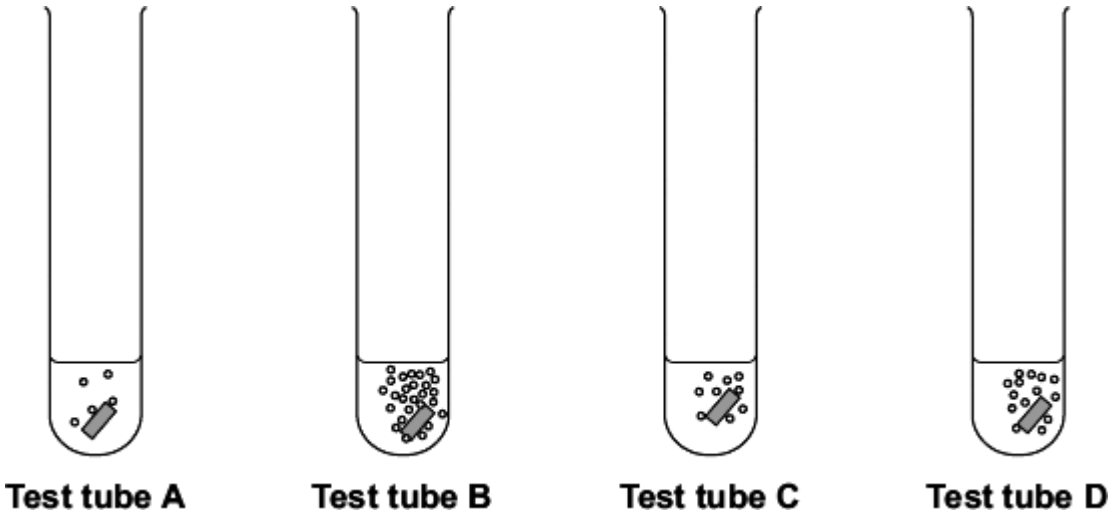
(ii) How would these measurements show that the reaction is exothermic?

_____

(1)

The student investigated how changing the concentration of the hydrochloric acid affects this reaction.

Each test tube contained a different concentration of hydrochloric acid.
The diagrams show the results of this experiment.



(b) Suggest **one** control variable in this investigation.

_____

_____

(1)

(c) (i) Which test tube, **A**, **B**, **C** or **D**, contained the greatest concentration of hydrochloric acid?

Test tube ☐

(1)

(ii) Why did you choose this test tube?

_____

_____

(1)

(d) The student predicted that if the temperature of the acid was increased the reaction would take place faster.

Tick (✓) **two** statements in the table which explain why.

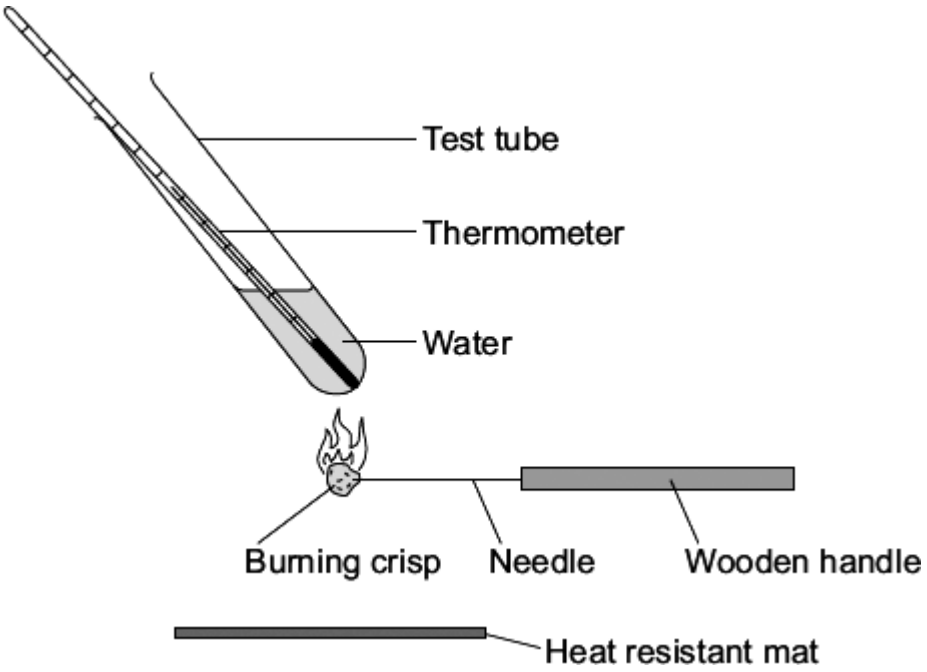
Statement	Tick (✓)
The particles move faster	
The particles collide with less energy	
The particles collide more often	
The particles are bigger	

(2)

(Total 8 marks)

Q12.

A student investigated the amount of energy released when four different makes of plain salted crisps were burned.



The following method was used for each make of plain salted crisp. The pieces of crisp were all the same size.

- The starting temperature of the water was measured.

- The piece of crisp was burned underneath the test tube.
- The final temperature of the water was measured.

(a) The results of the investigation are shown in the table.

	Make 1	**Make 2**	**Make 3**	**Make 4**
Final temperature of the water in °C	26	25	29	25
Starting temperature of the water in °C	19	20	20	21
Temperature rise of the water in °C	7	5	9	

(i) Calculate the temperature rise for **make 4**.

_____

Temperature rise = _____ °C

(1)

(ii) Which make of crisp, **1**, **2**, **3** or **4**, releases the most energy?

Make _____

Give a reason for your answer.

_____

_____

(2)

(b) The energy needed by a student is about 9000 kJ each day.

(i) One large bag of crisps states that the energy released by the crisps is 240 kcal.

Calculate the energy of this bag of crisps in kJ.

1 kcal = 4.2 kJ

_____

_____

Answer = _____ kJ

(2)

(ii) Eating too many crisps is thought to be bad for your health.

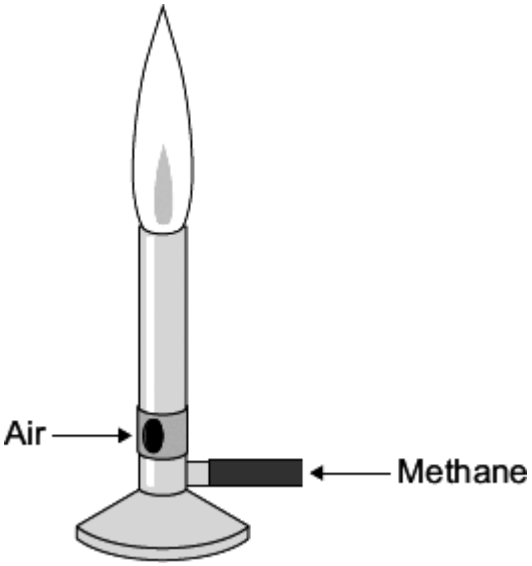
Use the information above and your knowledge to explain why.

(2)

(Total 7 marks)

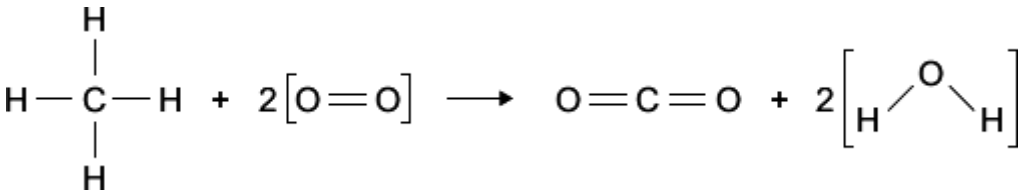
Q13.

A Bunsen burner releases heat energy by burning methane in air.



(a) Methane (CH_4) reacts with oxygen from the air to produce carbon dioxide and water.

(i) Use the equation and the bond energies to calculate a value for the energy change in this reaction.



Bond	Bond energy in kJ per mole
C — H	414
O = O	498
C = O	803
O–H	464

Energy change = _____ kJ per mole

(3)

(ii) This reaction releases heat energy.

Explain why, in terms of bond energies.

(2)

(b) If the gas tap to the Bunsen burner is turned on, the methane does not start burning until it is lit with a match.

Why is heat from the match needed to start the methane burning?

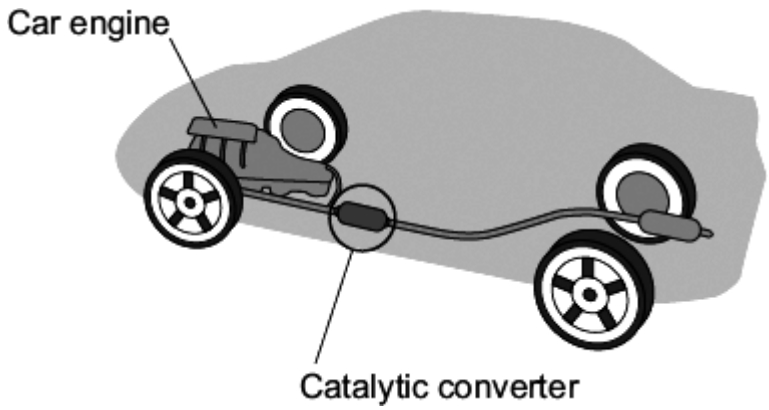
(1)

(Total 6 marks)

Q14.

Read the information about car engines.

> Burning petrol in air is an exothermic reaction. This reaction is used in car engines.
>
> When petrol burns it produces harmful substances such as nitrogen oxides and carbon monoxide.
>
> A catalytic converter stops these harmful substances being released into the air.



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

(i) The exothermic reaction makes the temperature

of the engine

decrease.

increase.

stay the same.

(1)

(ii) This is because during

exothermic reactions

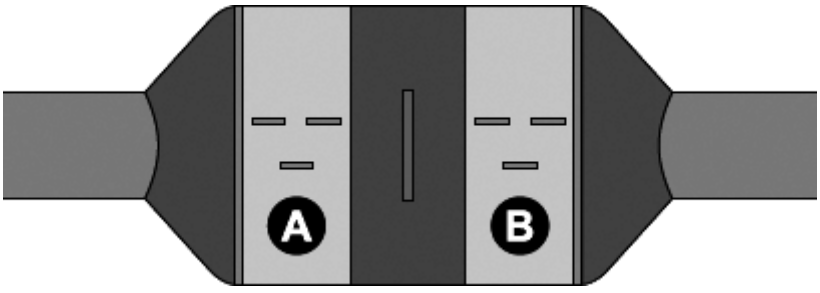
energy is taken in from the surroundings.

energy is given out to the surroundings.

there is no energy change.

(1)

(b) The diagram shows a catalytic converter which removes harmful substances.
The catalytic converter has two parts, **A** and **B**, which contain different catalysts.



(i) The equation for the reaction that takes place in part **A** is:

$$2NO \rightarrow N_2 + O_2$$

Which **one** of the substances shown in the equation is a compound?

Give the formula of this compound.

_____

(1)

(ii) The equation for the reaction that takes place in part **B** is:

$$2CO + O_2 \rightarrow 2CO_2$$

Why is it important to stop carbon monoxide (CO) from being released into the air?

_____

_____

(1)

(c) The table lists some statements about catalysts. Only **two** statements are correct.

Tick (✓) the **two** correct statements.

Statement	Tick (✓)
A catalyst can speed up a chemical reaction.	
A catalyst is used up in a chemical reaction.	
Different reactions need different catalysts.	
A catalyst does **not** change the rate of a chemical reaction.	

(2)

(d) Modern catalytic converters contain nanosized particles of catalyst.
Less catalyst is needed when nanosized catalyst particles are used.

(i) Complete the sentence.

The size of nanosized particles is _____ than normal sized particles.

(1)

(ii) The catalysts contain platinum.

Suggest why a manufacturer of catalytic converters would want to use less catalyst.

_____

_____

(1)

(Total 8 marks)

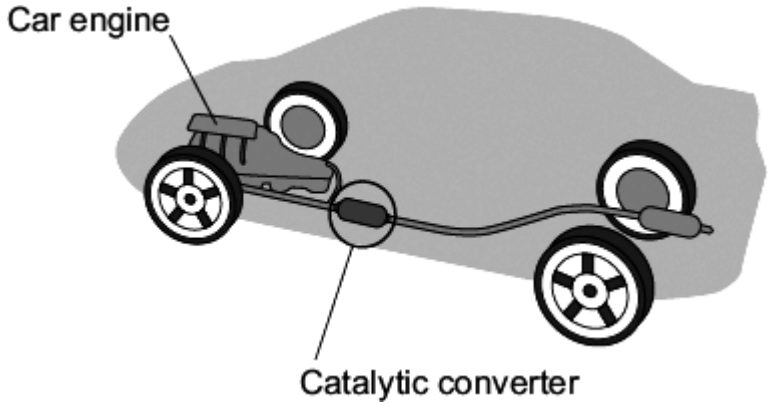
Q15.

Read the information about car engines.

Burning petrol in air is an *exothermic* reaction. This reaction is used in car engines.

When petrol burns it produces harmful substances such as nitrogen oxides and carbon monoxide.

A catalytic converter stops these harmful substances being released into the air.



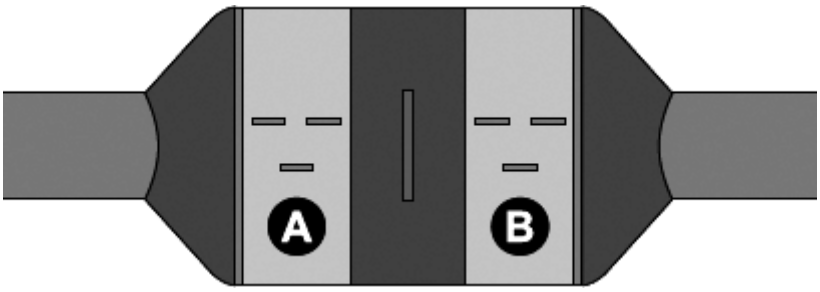
(a) The reaction is *exothermic*. What is the meaning of *exothermic*?

_____

_____

(1)

(b) The catalytic converter has two parts shown as **A** and **B** in the diagram.



Part **A** contains a catalyst made from platinum and rhodium.

Part **B** contains a catalyst made from platinum and palladium.

(i) Why are catalysts used in chemical reactions?

_____

_____

(1)

(ii) One reaction in part **A** is shown by this equation.

$$2NO \rightarrow N_2 + O_2$$

Suggest why this reaction helps the environment.

_____

_____

(1)

(iii) The equation for one of the reactions in part **B** is shown below.

Balance this equation.

$$\_\_\_\_\ CO + O_2 \rightarrow \_\_\_\_\ CO_2$$

(1)

(iv) The catalytic converter works for many years without replacing the catalyst.

Explain why the catalyst does not need to be replaced.

_____

_____

(1)

(v) Suggest why different catalysts are used in parts **A** and **B**.

_____

_____

(1)

(c) Modern catalytic converters contain nanosized particles of catalyst. Using nanosized particles reduces the cost of the catalytic converter.

Suggest and explain why the use of nanosized catalyst particles reduces the cost of the catalytic converter.

Your answer should include information about the size and surface area of the particles.

_____

_____

_____

_____

_____

_____

(3)

(Total 9 marks)

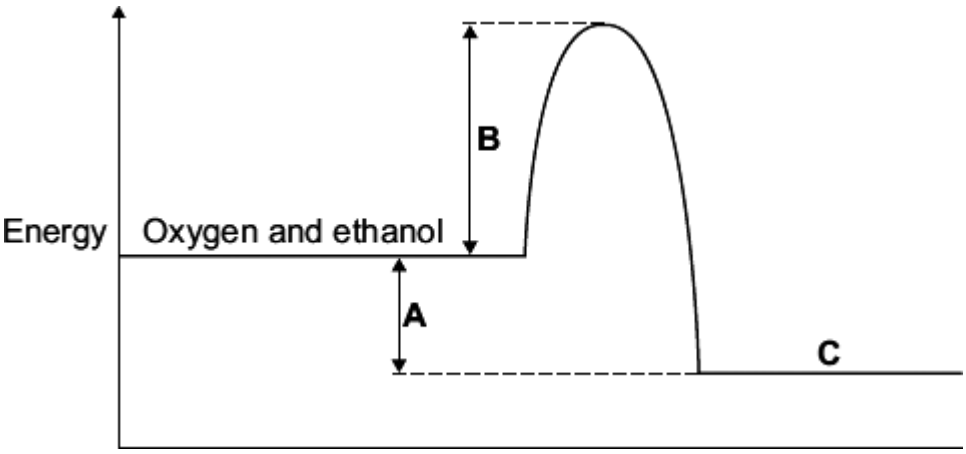
Q16.

V2 rockets were used during the Second World War.

By aronsson [CC BY-SA 2.0], via Flickr

V2 rockets were powered by liquid oxygen and ethanol. Oxygen and ethanol react to produce carbon dioxide and water.

The energy level diagram represents the energy changes during this reaction.



(a) On the energy level diagram what is represented by the letter:

A _____

B _____

C _____

(3)

(b) What type of reaction is represented by this energy level diagram?

_____

_____

(1)

(Total 4 marks)

Q17.

Hydrogen peroxide is often used to bleach or lighten hair.

Hydrogen peroxide slowly decomposes to produce water and oxygen.

(a) The equation for the reaction can be represented using structural formulae.

$$2\ H-O-O-H \longrightarrow 2\ H-O-H + O=O$$

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

Bond	Bond energy in kJ per mole
H – O	464
O – O	146
O = O	498

_____

_____

_____

_____

Energy change = _____ kJ

(3)

(b) Explain, in terms of bond making and bond breaking, why the reaction is exothermic.

(1)

(Total 4 marks)

Q18.

Read the information in the box.

Flash powder is used to produce special effects at pop concerts.

Flash powder contains aluminium. The powder burns with a bright white flame and gives out lots of heat and light. It also produces white smoke.

The flash powder is placed on stage in a special container. At the bottom of the container there is a thin piece of wire. When the flash is needed, electricity is passed through the wire. The wire gets hot and starts the aluminium burning.

(a) When aluminium burns the reaction is exothermic.

Give **one** piece of information from the box which shows that the reaction is exothermic.

(1)

(b) The hot wire provides energy to start the aluminium burning.

Draw a ring around the name given to the energy needed to start a chemical reaction.

activation energy **potential energy** **solar energy**

(1)

(c) When aluminium burns it reacts with oxygen to make aluminium oxide.

Complete the word equation for this reaction.

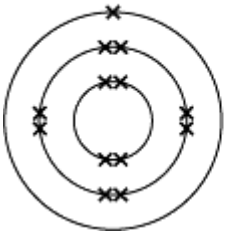
aluminium + _____ → _____

(1)

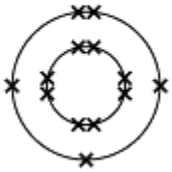
(d) An aluminium atom has 13 electrons.

Which diagram, **A**, **B** or **C**, represents the electronic structure of an aluminium atom?

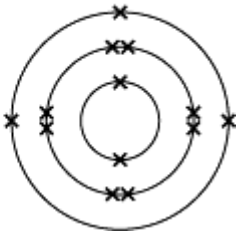
A



B



C



The electronic structure of an aluminium atom is diagram ☐

(1)

(e) The white smoke produced is aluminium oxide.

Aluminium oxide contains aluminium ions (Al^{3+}) and oxide ions (O^{2-}).

Draw a ring around the correct word in each box to complete each sentence.

(i) Electrons have

a negative
no
a positive

charge.

(1)

(ii) When an aluminium atom (Al) turns into an aluminium ion (Al^{3+})

it

gains
loses
shares

three electrons.

(1)

(iii) When an oxygen atom (O) turns into an oxide ion (O^{2-})

it	gains loses shares	one two three	electrons.

(2)
(Total 8 marks)

Q19.

Read the information in the box.

Flash powder is used to produce special effects at pop concerts.

Flash powder contains aluminium. The powder burns with a bright white flame and gives out lots of heat and light. It also produces white smoke.

The flash powder is placed on stage in a special container. At the bottom of the container there is a thin piece of wire. When the flash is needed, electricity is passed through the wire. The wire gets hot and starts the aluminium burning.

(a) When aluminium burns the reaction is *exothermic*.

What is the meaning of *exothermic*?

_____

_____

(1)

(b) The hot wire provides energy to start the aluminium burning.

What is the name given to the heat energy needed to start a chemical reaction?

_____ energy

(1)

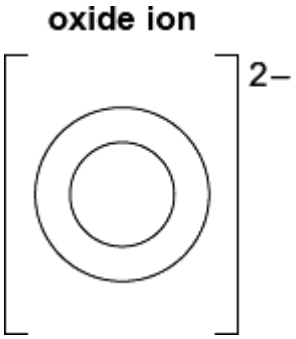
(c) The white smoke produced is aluminium oxide.

Aluminium oxide contains aluminium ions (Al^{3+}) and oxide ions (O^{2-}).

(i) Complete the diagram to show the electronic structure of an oxide ion.

The atomic number of oxygen = 8

Use crosses (x) to represent the electrons.



(1)

(ii) The bonding in aluminium oxide is ionic.

What causes the aluminium ions and oxide ions to be held together strongly?

_____

_____

(1)

(Total 4 marks)

Q20.

Hydrogen peroxide decomposes slowly to give water and oxygen.

The reaction is *exothermic*.

$$2H_2O_2 \rightarrow 2H_2O + O_2$$

(a) In an *exothermic* reaction, energy is given out.

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

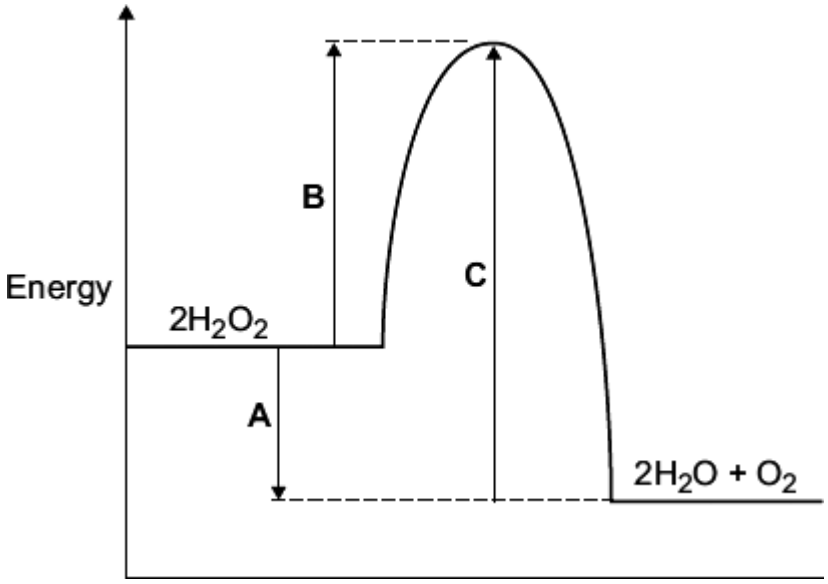
goes down.

In an *exothermic* reaction, the temperature

goes up.
stays the same.

(1)

(b) The energy level diagram for this reaction is shown below.



The energy changes, **A**, **B** and **C**, are shown on the diagram.

Use the diagram to help you answer these questions.

(i) Which energy change, **A**, **B** or **C**, is the activation energy?

(1)

(ii) Which energy change, **A**, **B** or **C**, shows that this reaction is exothermic?

(1)

(iii) Hydrogen peroxide decomposes quickly when a small amount of manganese(IV) oxide is added.

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

Hydrogen peroxide decomposes quickly because

manganese(IV) oxide is

a catalyst.
an element.
a solid.

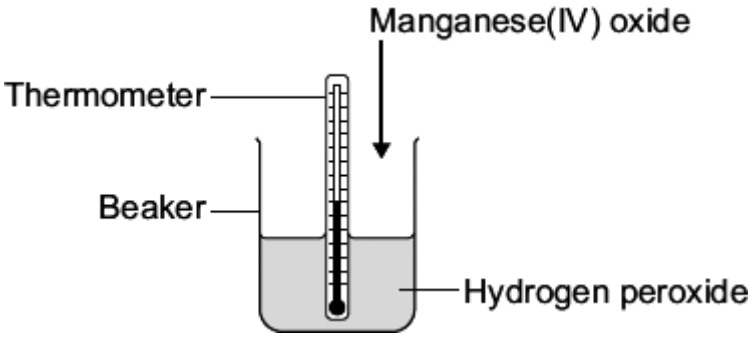
The manganese(IV) oxide has lowered the

activation energy.
boiling point.
temperature.

(2)

(c) A student did an experiment to find the amount of energy produced when hydrogen peroxide solution is decomposed using manganese(IV) oxide.

The apparatus the student used is shown in the diagram.



The student first measured the temperature of the hydrogen peroxide. Then the student added the manganese(IV) oxide, stirred the mixture and recorded the highest temperature.

(i) Suggest why the student stirred the mixture before recording the highest temperature.

_____

_____

(1)

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

Suggest how the student could change the apparatus so that less heat is lost.

_____

_____

(1)

(Total 7 marks)

Q21.

Hydrogen peroxide decomposes to give water and oxygen.

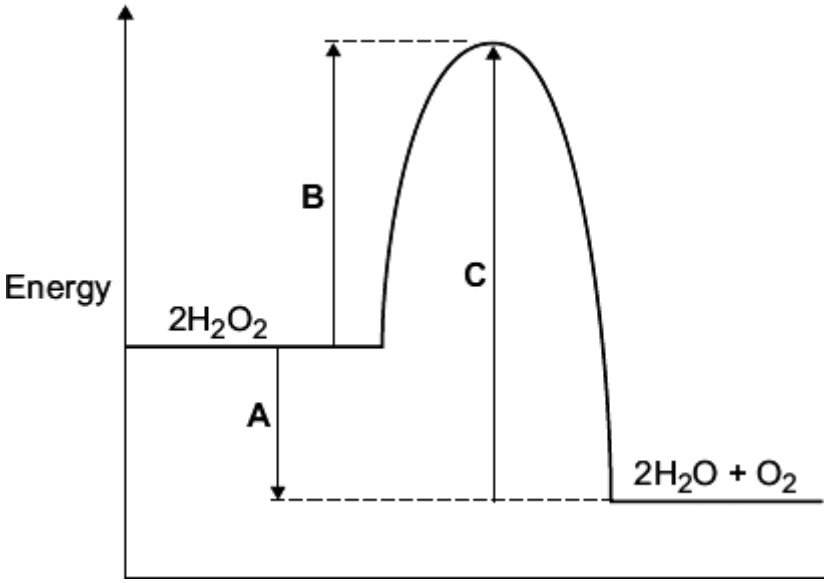
$$2H_2O_2 \rightarrow 2H_2O + O_2$$

The reaction is *exothermic*.

(a) Explain, in terms of bond breaking and bond making, why the decomposition of hydrogen peroxide is *exothermic*.

(1)

(b) The energy level diagram for this reaction is shown below.



The energy changes, **A**, **B** and **C**, are shown on the diagram.

Use the diagram to help you answer these questions.

(i) How do you know that this reaction is *exothermic*?

(1)

(ii) The decomposition of hydrogen peroxide is slow.
What does this suggest about energy change **B**?

(1)

(iii) Hydrogen peroxide decomposes quickly when a small amount of manganese(IV) oxide is added.

Explain why.

_____

_____

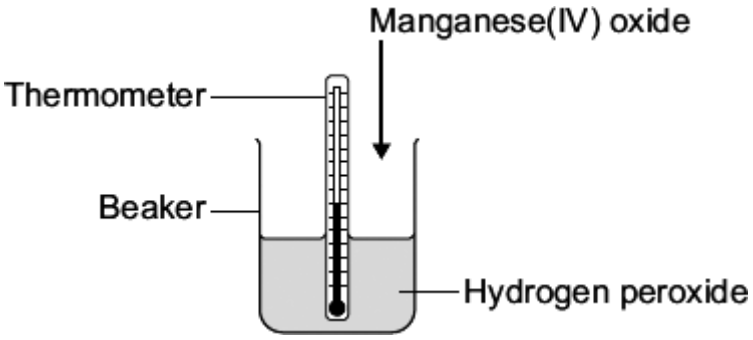
_____

_____

(2)

(c) A student did an experiment to find the amount of energy produced when hydrogen peroxide solution is decomposed using manganese(IV) oxide.

The apparatus the student used is shown in the diagram.



The student first measured the temperature of the hydrogen peroxide. Then the student added the manganese(IV) oxide and recorded the highest temperature.

The temperature rise was smaller than expected.

Suggest why.

_____

_____

_____

_____

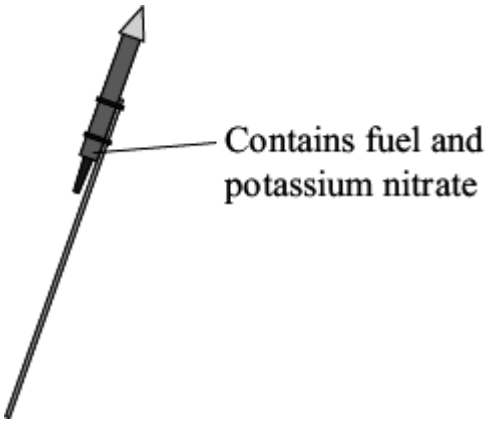
_____

(2)

(Total 7 marks)

Q22.

Firework rockets contain fuel and potassium nitrate.



The potassium nitrate provides oxygen for the fuel to react.

(a) The table shows how a student worked out the relative formula mass (M_r) of potassium nitrate.

Some of the numbers are missing.

Relative atomic masses (A_r): N = 14; O = 16; K = 39.

Name of atom (symbol)	**Number of atoms**	**A_r**	**Mass**
potassium (K)	1	39	39
nitrogen (N)	1	14	14
oxygen (O)		16	
		The M_r of potassium nitrate =	101

(i) The mass of oxygen is not shown in the table.

Draw a ring around the correct mass of oxygen.

16 **32** **48**

(1)

(ii) Draw a ring around the number of oxygen atoms in the formula of potassium nitrate.

1 **2** **3**

(1)

(b) When the fuel reacts with the oxygen an *exothermic* reaction takes place.

What does *exothermic* mean?

_____

_____

_____

_____

(2)

(c) The fuel contains carbon. Carbon reacts with oxygen to make carbon dioxide.

Which **two** statements in the table explain why carbon dioxide is a gas at room temperature?

Tick (✓) the **two** statements.

Statement	**Tick (✓)**
It has a giant structure	
It has a low boiling point.	
It is made of small molecules.	
It is made of ions.	

(2)

(Total 6 marks)

Q23.

During a thunderstorm lightning strikes the Eiffel Tower.

By M. G. Loppé [Public domain], via Wikimedia Commons

In lightning the temperature can reach 30 000 °C. This causes nitrogen and oxygen in the air to react, producing nitrogen oxide. This reaction has a high *activation energy* and is *endothermic*.

(a) Nitrogen and oxygen in the air do not react easily.

What makes nitrogen and oxygen react during thunderstorms?

_____

(1)

(b) Complete the word equation for the reaction of nitrogen with oxygen.

nitrogen + _____ → _____

(1)

(c) In an *endothermic* reaction, energy is taken in from the surroundings.

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

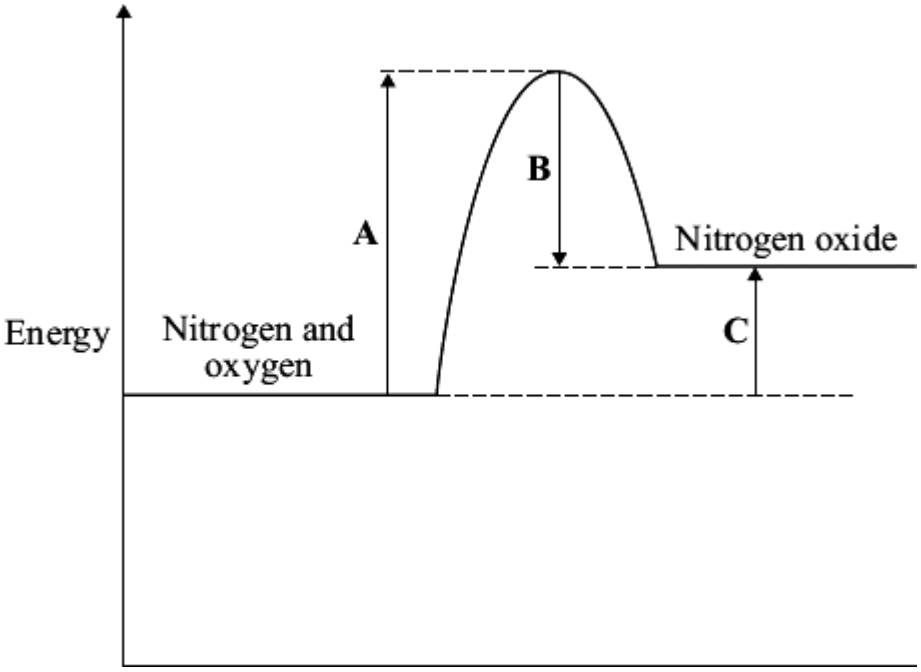
In an *endothermic* reaction, the energy needed to break existing bonds is

less than
more than
the same as

the energy released from forming new bonds.

(1)

(d) The energy level diagram for this reaction is shown.



Use the energy level diagram to help you to answer these questions.

(i) Which energy change, **A**, **B** or **C**, represents the *activation energy*?

(1)

(ii) Which energy change, **A**, **B** or **C**, shows that this reaction is *endothermic*?

(1)

(Total 5 marks)

Q24.

During a thunderstorm lightning strikes the Eiffel Tower.

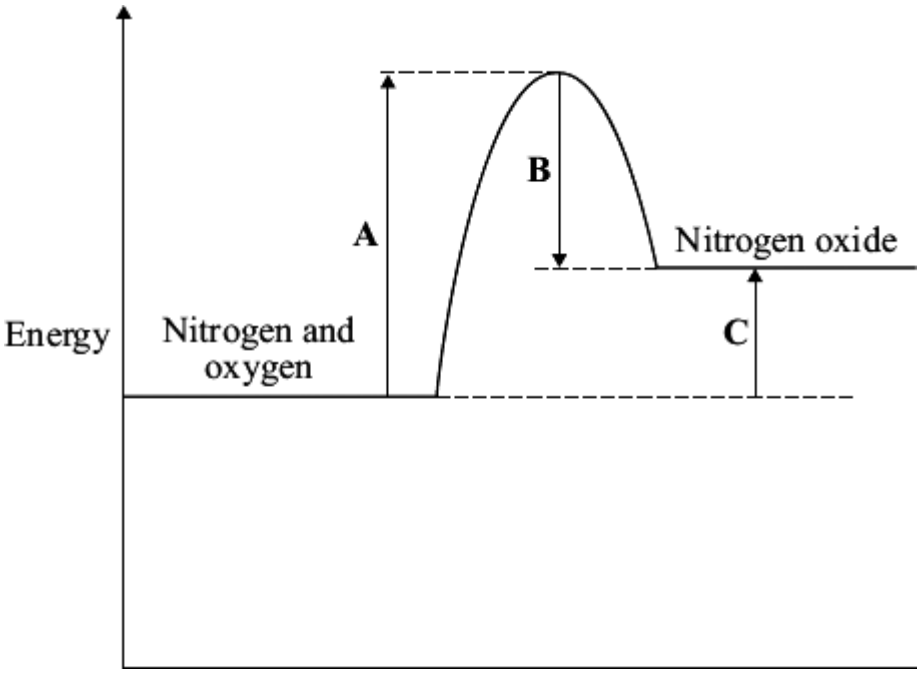
By M. G. Loppé [Public domain], via Wikimedia Commons

In lightning the temperature can reach 30 000 °C. This causes nitrogen and oxygen in the air to react, producing nitrogen oxide. This reaction has a high *activation energy* and is *endothermic*.

An equation that represents this endothermic reaction is:

$$N_2 \quad + \quad O_2 \quad \rightarrow \quad 2NO$$

The energy level diagram for this reaction is given below.



(a) The energy level diagram shows that this reaction is *endothermic*.

Explain how.

_____

_____

(1)

(b) What is meant by the term *activation energy*?

_____

_____

(1)

(c) The equation showing the structural formulae of the reactants and products is

$$N \equiv N \quad + \quad O = O \quad \rightarrow \quad 2\ N = O$$

Bond	Bond energy in kJ
N ≡ N	945
O = O	498
N = O	630

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

_____

_____

_____

_____

Energy change = _____ kJ

(3)

(ii) In terms of bond energies, explain why this reaction is endothermic.

_____

_____

_____

(1)

(Total 6 marks)

Q25.

(a) Read the article about the mineral strontianite.

Strontianite is a mineral that was discovered near the village of Strontian in Scotland. At first some scientists thought that strontianite was barium carbonate.

Strontianite

In 1790, Professor Adair Crawford and William Cruikshank were both lecturers in chemistry and doctors of medicine. They investigated the properties of strontianite. They found that strontianite had different properties from barium carbonate. They concluded that strontianite contained a new element.

After this, other scientists also showed that strontianite and barium carbonate had different properties. Strontianite is now known to be strontium carbonate.

Rob Lavinsky, iRocks.com – CC-BY-SA-3.0 [CC-BY-SA-3.0], via Wikimedia Commons

(i) What evidence did Crawford and Cruikshank use to prove that strontianite was

not barium carbonate?

_____

_____

(1)

(ii) Crawford and Cruikshank's conclusion was immediately accepted by other scientists. Suggest why.

_____

_____

(1)

(iii) How was the reliability of the work of Crawford and Cruikshank confirmed?

_____

_____

(1)

(b) One of Crawford and Cruikshank's experiments was repeated in a school laboratory.

Samples of strontianite and barium carbonate were reacted with hydrochloric acid to produce strontium chloride and barium chloride.

Solid strontium chloride and solid barium chloride were separately added to water. The change in temperature of the water was measured.

The results of the experiments are shown below.

	Experiment 1 Strontium chloride dissolved in water	**Experiment 2** Barium chloride dissolved in water
Temperature of water before adding the chloride in °C	19.5	19.6
Temperature of water after adding the chloride in °C	21.2	17.5

(i) State **one** variable that should be controlled to make it a fair test.

_____

_____

(1)

(ii) Which experiment, **1** or **2**, is endothermic?

Explain how you know.

Experiment ☐ because _____

_____

(1)

(iii) The results prove that strontium chloride and barium chloride must be different even if all of the variables had not been controlled when they were dissolved. Explain why.

_____

_____

(1)

(c) In 1808, Humphry Davy was the first person to extract strontium. He did this by the electrolysis of molten strontium chloride. Strontium formed at the negative electrode.

Suggest why strontium ions are attracted to the negative electrode.

_____

_____

(1)

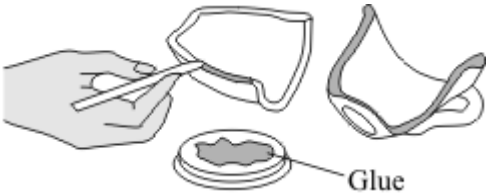
(Total 7 marks)

Q26.

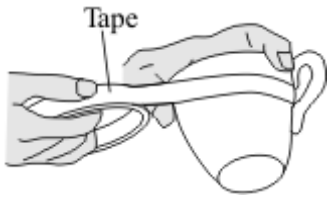
The following steps show how to use a type of glue.

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 Assemble the pieces to be joined and then hold them together with tape.



Step 4 Leave the glue to set.

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

(i) This reaction is exothermic.

Complete the sentence below using a word or phrase from the box.

decrease	**increase**	**stay the same**

During the reaction the temperature of the mixture will _____ .

(1)

(ii) When the glue sets it forms a giant covalent structure.

Draw a ring around **one** property that you would expect the set glue to have.

good conductor of electricity **low melting point** **high melting point**

(1)

(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) Complete the sentences below using words or phrases from the box.

decrease	**increase**	**stay 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) Put a tick (✓) next to the **two** reasons why an increase in temperature affects

the rate of reaction.

Reason	(✓)
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)

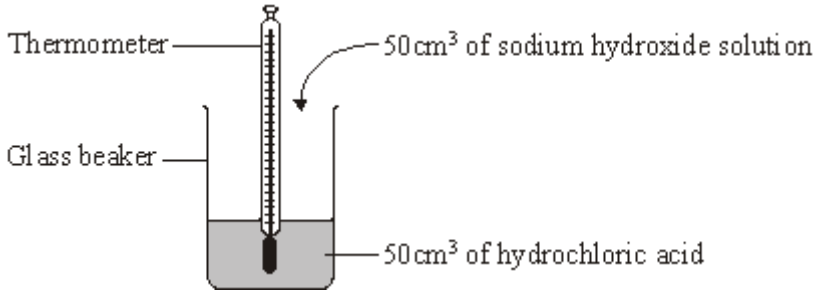
Q27.

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 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 change in °C	7.2	7.0	6.8	4.5

(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 stir the chemicals thoroughly.

_____

(1)

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

Explain 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

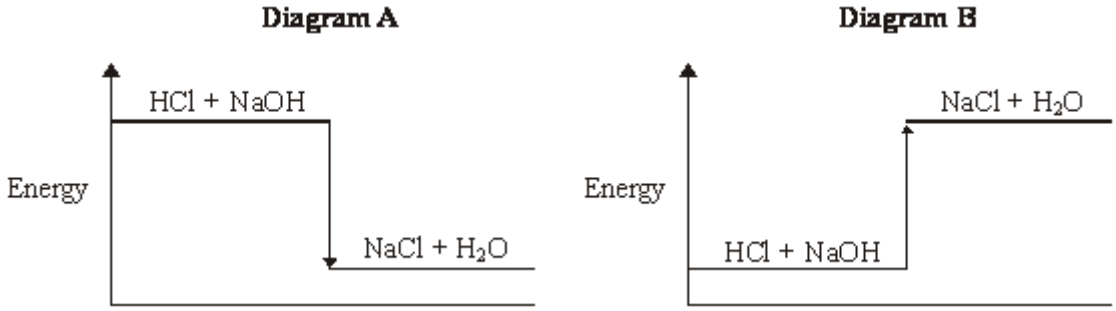
_____

Answer = _____ J

(1)

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

Explain why.



_____

_____

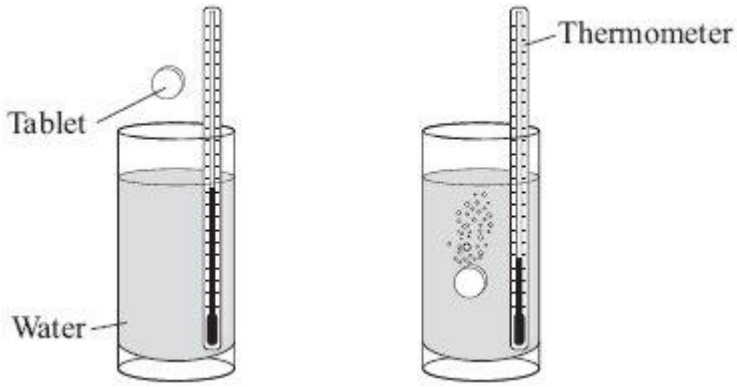
(1)

(Total 7 marks)

Q28.

An indigestion tablet contains sodium hydrogencarbonate and citric acid.

When the tablet is added to cold water a chemical reaction takes place and there is a lot of fizzing.



(a) The formula of the gas that causes the fizzing is CO_2

Name this gas _____ .

(1)

(b) This chemical reaction is endothermic.

(i) Tick (✓) the statement which describes what happens to the temperature of the solution.

Statement	Tick (✓)
The temperature of the solution will increase.	
The temperature of the solution will decrease.	
The temperature of the solution will stay the same.	

(1)

(ii) Tick (✓) the statement which describes what happens to the energy during the reaction.

Statement	Tick (✓)
Energy is given out to the surroundings.	
Energy is taken in from the surroundings.	
No energy is given out to or taken from the surroundings.	

(1)

(Total 3 marks)

Q29.

An airship caught fire when it was coming in to land in 1937. The airship was filled with hydrogen. A spark or flame ignited the hydrogen. The hydrogen reacted with oxygen in the air to produce water.

(a) Write a word equation for the reaction of hydrogen with oxygen.

_____

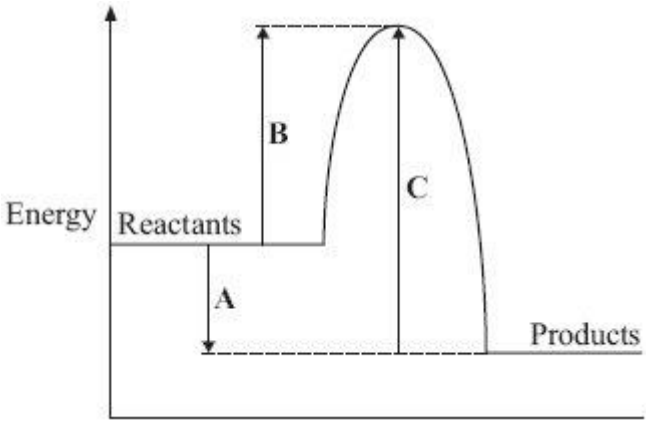
(1)

(b) Draw a ring around the correct answer in each box to complete this sentence.

When reactions take place, energy is [released / supplied] to break the existing bonds and energy is [released / supplied] when new bonds form.

(1)

(c) An energy level diagram for the reaction of hydrogen and oxygen is shown below.



Use the energy level diagram above to help you to answer these questions.

(i) Which energy change, **A**, **B** or **C**, represents the activation energy?

☐

(1)

(ii) Which energy change, **A**, **B** or **C**, shows that the reaction is exothermic?

☐

(1)

(iii) Explain why the hydrogen and oxygen needed a spark or flame to start the reaction.

_____

_____

(1)

(Total 5 marks)

Q30.

An airship caught fire when it was coming in to land in 1937. The airship was filled with hydrogen. A spark or flame ignited the hydrogen. The hydrogen reacted with oxygen in the air to produce water.

(a) The equation for the reaction can be represented using structural formulae for the chemicals.

$$2\ H-H + O=O \rightarrow 2\ H-O-H$$

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

Bond	Bond energy in kJ per mole
H – H	436
O = O	498
O – H	464

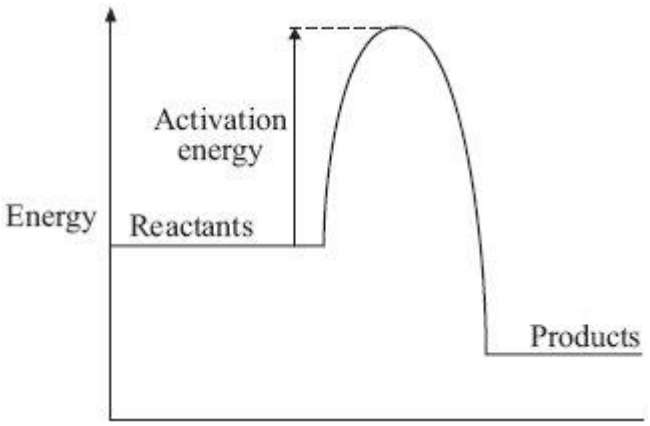
Energy change = _____ kJ

(3)

(b) Explain, in terms of making and breaking bonds, why this reaction is exothermic.

(1)

(c) Use the energy level diagram for this reaction to help you to answer these questions.



(i) The hydrogen did **not** burn until ignited by a spark or flame.

Explain why.

_____

(1)

(ii) Platinum, a transition metal, causes hydrogen to ignite **without** using a spark or flame.

Explain why.

_____

_____

_____

_____

(2)

(Total 7 marks)

Q31.

Distress flares are used to attract attention in an emergency.

Flares often contain magnesium. Magnesium burns to form magnesium oxide.

(a) The distress flare burns with a bright flame because the reaction is very *exothermic*.

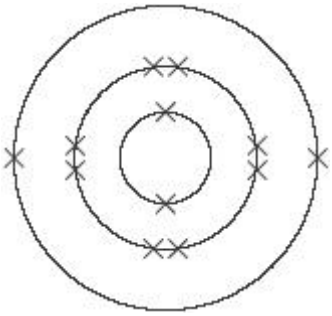
Complete the following sentence using the correct words from the box.

gives out heat	**stores heat**	**takes in heat**

An *exothermic* reaction is one which _____ .

(1)

(b) The diagram shows the electronic structure of a magnesium atom.
The atomic (proton) number of magnesium is 12.



Magnesium atom

The atomic (proton) number of oxygen is 8.

Which diagram, **A**, **B**, **C** or **D**, shows the electronic structure of an oxygen atom?

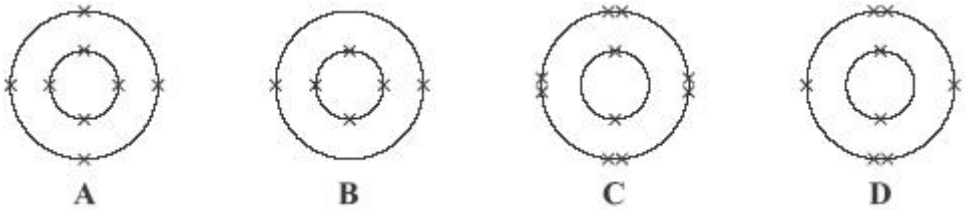
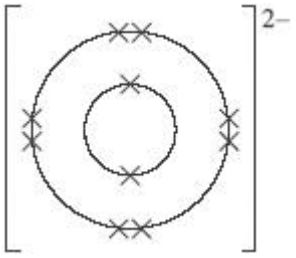


Diagram _____

(1)

(c) Magnesium ions and oxide ions are formed when magnesium reacts with oxygen. The diagram shows the electronic structure of an oxide ion.



Oxide ion

Which diagram, **J**, **K**, **L** or **M**, shows the electronic structure of a magnesium ion?

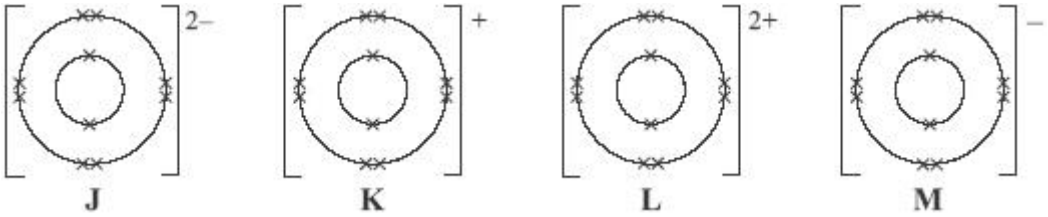


Diagram _____

(1)

(d) Indigestion tablets can be made from magnesium oxide. The magnesium oxide neutralises some of the hydrochloric acid in the stomach.

Draw a ring around the name of the salt formed when magnesium oxide reacts with hydrochloric acid.

magnesium chloride **magnesium hydroxide** **magnesium sulfate**

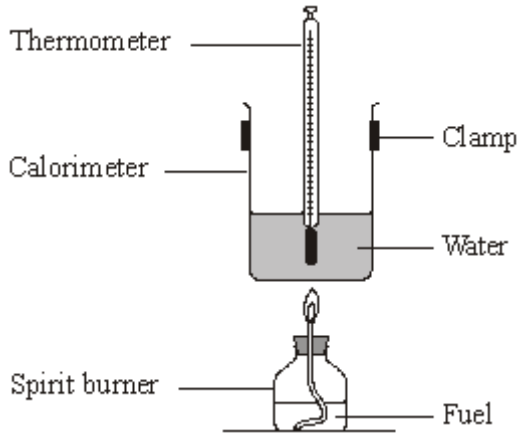
(1)

(Total 4 marks)

Q32.

A student burned four fuels and compared the amounts of energy they produced.

The student set up the apparatus as shown in the diagram.



The heat produced when each fuel was burned was used to raise the temperature of 100 g of water. The student noted the mass of fuel burned, the increase in temperature and whether the flame was smoky.

The results are shown in the table.

Fuel	Mass of fuel burned (g)	Temperature increase (°C)	Type of flame
Ethanol	4	24	Not smoky
Methanol	3	9	Not smoky
Peanut oil	2	20	Smoky
Vegetable oil	1	15	Smoky

(a) The student suggested that the vegetable oil was the best fuel for producing heat.

Explain why.

_____

_____

_____

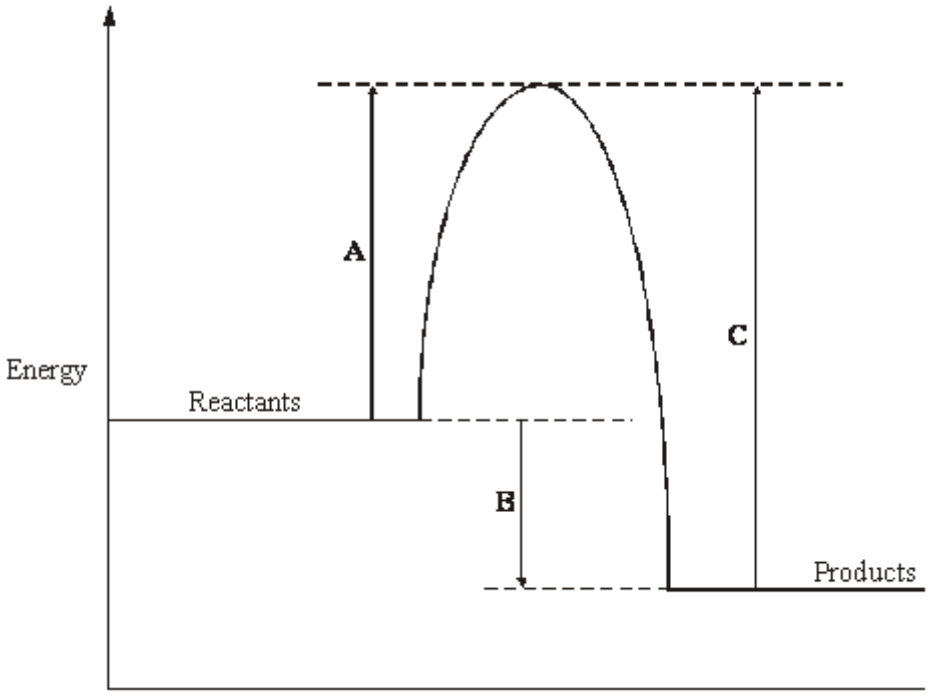
_____

(2)

(b) Suggest an environmental problem that could be caused when large amounts of vegetable oil are burned. Suggest how the problem could be overcome.

(2)

(c) An energy level diagram for the burning of vegetable oil is shown below.



Which of the energy changes **A**, **B** or **C:**

(i) represents the activation energy

(1)

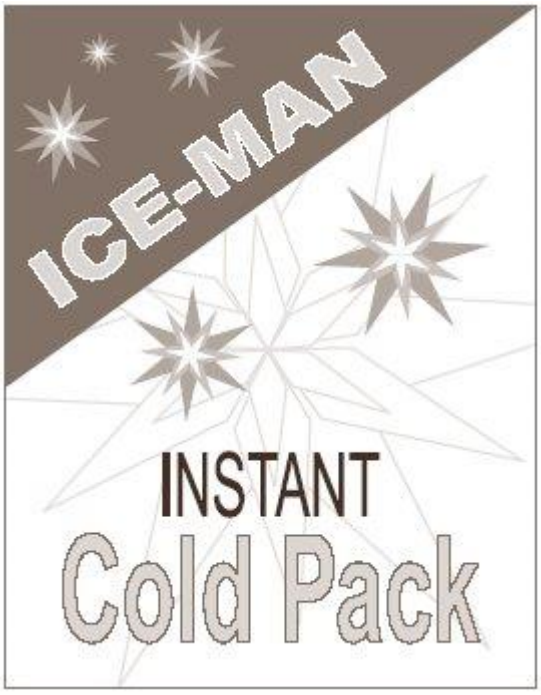
(ii) shows the amount of energy given out during the reaction?

(1)

(Total 6 marks)

Q33.

Instant cold packs are used to treat sports injuries.



One type of cold pack has a plastic bag containing water. Inside this bag is a smaller bag containing ammonium nitrate.

The outer bag is squeezed so that the inner bag bursts. The pack is shaken and quickly gets very cold as the ammonium nitrate dissolves in the water.

(a) **One** of the statements in the table is correct.

Put a tick (✓) next to the correct statement.

Statement	(✓)
The bag gets cold because heat energy is given out to the surroundings.	
The bag gets cold because heat energy is taken in from the surroundings.	
The bag gets cold because plastic is a good insulator.	

(1)

(b) Draw a ring around the word that best describes the change when ammonium nitrate dissolves in water.

electrolysis **endothermic** **exothermic**

(1)

(c) Suggest and explain why the pack is shaken after the inner bag has burst.

_____

_____

_____

_____

(2)

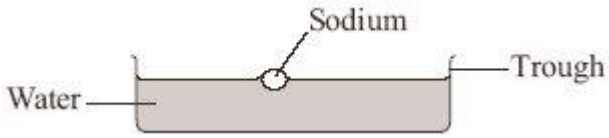
(Total 4 marks)

Q34.

(a) Read a student's report about the reaction between sodium and water.

The reaction between sodium and water

A small piece of sodium was added to some water in a trough.



The sodium floated and started to react.

The sodium moved along the surface of the water and melted to give a ball of molten metal.

The ball became smaller and smaller until it had all gone.

A gas was given off and a colourless solution was left.

The word equation for this reaction is:

sodium + **water** → **sodium hydroxide** + **hydrogen**

Use the information from the student's report to answer these questions.

(i) Which information shows that sodium has a low density?

_____

(1)

(ii) Which information shows that the reaction is exothermic?

_____

(1)

(iii) Name the gas given off.

_____

(1)

(b) The periodic table on the Data Sheet may help you to answer these questions.

(i) Sodium is in Group 1.

Name a Group 1 element that is more reactive than sodium.

_____

(1)

(ii) Here are some statements about Group 1 elements.

Only **two** of these statements are correct.

Put a tick (✓) next to the two correct statements.

Statement	(✓)
They are halogens	
They are metals	
They form covalent compounds	
They form ions with a +1 charge	

(2)

(c) Dimitri Mendeleev put forward his periodic table in 1869.

Complete these sentences by drawing a ring around the correct answer.

(i) Mendeleev arranged the elements in order of their

atomic weight
density
reactivity

(1)

(ii) The table is called a periodic table because elements with

identical
the same
similar

properties occur at regular intervals.

(1)

(iii) The vertical columns are known as

groups
periods
rows

(1)

(d) How did Mendeleev overcome the problem of undiscovered elements when he designed his table?

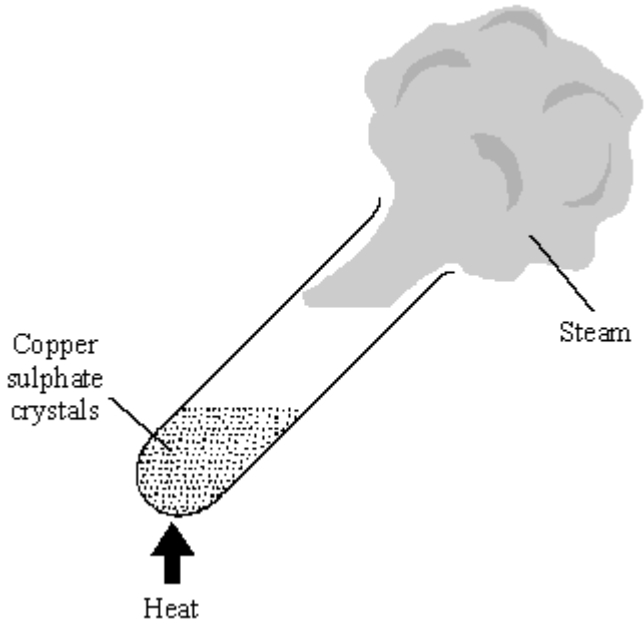
_____

(1)

(Total 10 marks)

Q35.

A student heated some blue copper sulphate crystals. The crystals turned into white copper sulphate.



(a) The blue copper sulphate had to be heated to change it into white copper sulphate.

State whether the reaction was exothermic or endothermic. _____

Explain your answer.

_____

_____

(1)

(b) The word equation for this reaction is shown below.

hydrated copper sulphate (blue) [+ heat energy] $\rightleftharpoons$ anhydrous copper sulphate (white) + water

(i) What does the symbol $\rightleftharpoons$ tell you about this reaction?

_____

(1)

(ii) How could the student turn the white powder back to blue?

_____

(1)

(Total 3 marks)

Mark schemes

Q1.

(a) (i) aluminium oxide

ignore (III) after aluminium

1

(ii) (because it provides) heat / energy (to overcome activation energy)

1

(b) (i) contains only one sort of atom

1

(ii) the atoms (in cast iron) are different sizes

*any mention of molecules, maximum **1** mark*

*accept layers are distorted **or** structure is disrupted*

1

which prevents the layers / rows sliding

accept an answer in terms of pure iron being softer than cast iron for both marks

1

(c) (i) because aluminium is more reactive than carbon

'it' = aluminium must be a comparison between the elements

or

because aluminium is above carbon in the reactivity series

*do **not** accept any comparison of the reactivity of aluminium and iron*

1

(ii) reduces / lowers the temperature for the process **or** lowers the operating temperature **or** allows ions to move

ignore any temperature values

allow reduces the (effective) melting point (of Al_2O_3)

1

(iii) 3

accept multiples

1

(iv) electrons are gained (by Al^{3+})

ignore any numbers

ignore any reference to oxygen

1

(v) electrodes are made of carbon

allow graphite / coke

1

oxygen is produced (at the positive electrode / anode)

accept $2O^{2-} \rightarrow O_2 + 4e^-$

1

so the electrodes react with the oxygen / are oxidised

1

producing carbon dioxide (gas)

accept $C + O_2 \rightarrow CO_2$ *for marking points 3 and 4.*

1

[13]

Q2.

(a) neutron(s)

answers can be in either order

1

proton(s)

1

(b) same number (17) protons **or** same number electrons

if candidate chooses to quote numbers, they must be correct

1

different numbers of neutrons (^{35}Cl has 18 and ^{37}Cl has 20)

1

(c) (i) −184kJ / mol

*correct answer with or without working gains **3** marks*

*allow **2** marks for 184 kJ / mol*

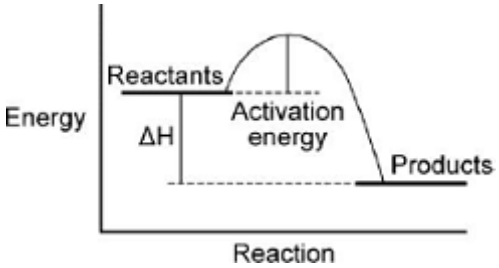
*If answer incorrect award up to **2** marks for any two of the steps below:*

- *bonds broken: (436 + 242) = 678 (kJ)*
- *bonds formed: (2 × 431) = 862 (kJ)*
- *bonds broken − bonds formed*

allow ecf for arithmetical errors

3

(ii)



the reactants and the products at the correct level

ignore labels on the axes

1

ΔH correctly labelled

allow −538 if in correct place

1

E_a correctly labelled

*correctly labelled endothermic reaction gains max. **2** marks*

1

[10]

Q3.

(a) (i) endothermic

could be answered by indicating the correct word in the box

1

(ii) final temperatures got lower **or** temperature went down

ignore comments on energy

1

(b) polystyrene / plastic cup **or** description of insulation / lagging container

ignore references to a lid

1

because (polystyrene) is an insulator **or** prevents heat / energy gain (and so temperature is more accurate)

*allow references to heat loss **or** glass conducts / absorbs heat*

1

(c) **variable**: volume **or** mass **or** amount of water

***1** mark for variable and **1** mark for reason linked to that variable*

*maximum of **4** marks for two variables and two explanations*

reason: the greater the volume / mass of water, the more heat energy it contains **or** the smaller the temperature change will be

*do **not** allow 'time taken to heat'*

variable: start temperature **or** temperature of water

reason: the higher the start temperature, the more heat energy it contains **or** the higher the final temperature will be

*do **not** allow higher temperature change*

variable: the time at which the temperature is measured

reason: if left longer may gain heat energy from surroundings **or** warm up **or** if measured too soon not all ammonium chloride will have dissolved so less temperature change

variable: rate of dissolution **or** speed of dissolving **or** amount of stirring

reason: if it dissolves faster **or** is stirred faster then it will cool more quickly **or** small particles dissolve faster

max. 4

(d) (i) all 7 points correct

*at least 4 points plotted correctly scores **1** mark*

2

(ii) straight line through first 3 or 4 points

lines must be drawn with a ruler

1

straight line through last three points

*if no other marks awarded allow curve joining lines for **1** mark*

1

(iii) valid extrapolation of line back to mass of 0 g

1

correct value read from graph

*award **1** mark for 20 − 21 if no extrapolation shown*

1

(e) not all of the ammonium chloride would dissolve

*allow water limiting factor **or** all water used*

1

so no more heat would be absorbed

or

the solution is saturated (1)

*allow water limiting factor **or** all water used*

so some ammonium chloride remains solid **or** not all will dissolve (1)

1

(f) greater volume of water was used **or** volume was twice as large

allow different volume of water

1

so temperature decrease was less than the first student's result

allow so final temperature was higher

or

starting temperature / room temperature was higher (1)

so final temperature was greater than the first student's result (1)

*accept by 6 °C **or** was any value in range 26 − 27°C*

1

[18]

Q4.

(a) (i) the more sodium hydrogencarbonate the greater the temperature change

accept examples from the table

1

up to 8 spatula measures

accept any correct indication of when change occurs

1

then the temperature change is constant

*if no marks awarded allow **1** mark for:*
the more sodium hydrogencarbonate the lower the final temperature

1

(ii) energy is taken in from the surroundings **or** endothermic

1

(b) (i) gas / carbon dioxide / steam / water is produced

*accept carbon dioxide is a gas **or** steam / water is a gas*
allow gas / air expands when heated

1

(ii) no, because (reaction) is exothermic
or
yes, to start the reaction

allow no, because (reactants) were formed by heating
ignore references to cooling

1

(c) (i) 84

*correct answer with or without working gains **2** marks*
*if no answer or incorrect answer then evidence of 23 +1 + 12 + (3 × 16) gains **1** mark*

2

(ii) 14.29

accept rounding to 14.3 or 14
allow ecf from (c)(i)

1

[9]

Q5.

(a) (i) 42 000

*correct answer gains **2** marks with or without working*
allow 42 kJ
*if answer incorrect : correct substitution 500 x 4.2 x 20 gains **1** mark*

2

(ii) any **two** from:

- eye protection
- lab coat
- heat-proof mat

- (heat-proof) gloves
- (long) hair tied back
- stand up
- secure the beaker

2

(iii) Stir the water before measuring the temperature.

1

Place a lid on the beaker.

1

(b) the products → S

1

the activation energy → Q

1

the energy released by the reaction → P

1

(c) carbon dioxide produced

it = propane

allow converse arguments

allow greenhouse gas / global warming / atmospheric pollution

(crude oil / propane) non-renewable

1

allow crude oil running out

1

[11]

Q6.

(a) air

1

(b) recycle

allow re-use

1

(unreacted) nitrogen and hydrogen

allow N_2 and H_2

1

(c) $N_2 + \mathbf{3}H_2 \rightarrow \mathbf{2}NH_3$

allow correct multiples

1

(d) *allow converse arguments*

ignore references to compromise

because a higher temperature would reduce (equilibrium) yield

allow higher temperature favours backward reaction

1

because a lower temperature would reduce rate

1

(e) (i) (energy of) reactants greater than (energy of) products

allow converse

allow (overall) energy decreases

allow energy required to break bonds is less than the energy released making bonds

1

(ii) line starting and finishing at same levels but with lower peak

1

[8]

Q7.

(a) (i) $\Delta T = (64 - 17) = 47\ ^\circ C$

1

750 x 4.2 x 47

allow ecf using their ΔT

1

148 050

*correct answer gains **3 marks** with **or** without working*

ignore sign

allow 148.05 kJ

allow 148 kJ

1

(ii) 1085.7

*correct answer gains **2** marks with or without working.*

*allow answer in range 1080 – 1089 for **2 marks***

*allow answer in range 1080000 – 1089000 for **1 mark***

*if answer is incorrect allow 6/44 = 0.136 mol for **1 mark***

*allow (44 x their (a)(i))/(6 x 1000) correctly calculated for **2 marks***

*allow (44 x their (a)(i))/6 correctly calculated for **1 mark***

If they have used the given value of 144 000:

*Allow any answer in range 1051 - 1059 for **2 marks** with or without working.*

*allow any answer in range 1051000 – 1059000 for **1 mark***

2

(iii) repeat the experiment and then calculate the mean

1

any **one** from:

- use a lid
- insulate the beaker
  *do **not** allow flammable insulation*
- stir
- prevent draughts

1

(iv) inaccuracies likely to have similar effects
allow systematic errors

1

(b) (i) 8530
correct answer gains 3 marks with or without working.
If answer is incorrect;
(6 x 803) = 4818 gains 1 mark
(8 x 464) = 3712 gains 1 mark
correct addition of their calculated values gains 1 mark (ecf)

3

(ii) 6481 – 8530) = (-) 2049
ignore sign
allow ecf from (b)(i)

1

[12]

Q8.

(a) any **one** from:

- no method / electrolysis / equipment / technology
  *allow 'didn't know how to' **or** 'no knowledge'*
- aluminium is a very reactive metal
- high melting point
  allow 'couldn't heat it enough'
- potassium had not been discovered

1

(b) because others / scientists / they could not repeat the experiment
ignore he could not repeat the experiment

or
others / they could not obtain the same results

1

(c) reaction is endothermic **or**
reaction takes in heat / energy
accept activation energy

ignore rate / high temperature
ignore bonds broken

1

(d) (aluminium chloride + potassium) → aluminium + potassium chloride
in either order
accept correct formulae
ignore metal
ignore balancing

1

(e) when tested it had the properties of a metal
accept a test for a metal property eg conductivity / reaction with acid

1

properties were different (from other known metals)
accept properties compared with other metals

1

[6]

Q9.

(a) 22

1

(b) (i) exothermic

1

(ii) C

1

gives out most heat energy
accept has largest temperature change / increase
*allow has highest (final) temperature **or** hottest*

1

(c) (i) increases

1

(ii) blue
ignore pale / dark etc

1

(iii) reversible (reaction)
*allow goes both ways **or** two / either way*

1

(iv) anhydrous copper sulfate

1

[8]

Q10.

(a) gives out energy **or** heat

1

(b) (i) *accept qualified answers in terms of volume of gas related to time*

fast initially

1

slows down

1

reaction stops

accept reaction is now very slow

1

(b) (ii) 21

1

(iii) 84

*correct answer with or without working = **2** marks*
*allow ecf from (b)(ii) correctly calculated for **2** marks*
*allow evidence of 21/25 **or** (b)(ii)/25 for **1** mark*

2

(c) because they / particles have more energy / move faster

ignore particles move more / vibrate

1

(and so) particles collide more often / more frequently **or** particles more likely to collide

ignore collide faster
ignore more collisions

1

(and) more of the collisions are successful **or** particles collide with more energy / harder **or** more of the particles have the activation energy

accept more successful collisions

1

[10]

Q11.

(a) (i) the temperature at start

ignore reference to bubbles / heat

1

the temperature at end

*(measure) the temperature rise / change = **2** marks*
*(measure) the temperature **1** mark*

1

(ii) temperature would increase

allow it gets hot(ter) / warm(er) or heat given off
allow energy released / transferred

1

(b) any **one** from:

- volume of acid
  allow amount
  allow liquid
- temperature of acid
- size of magnesium ribbon
  allow volume / mass / amount
- surface area of magnesium
  ignore size of test tube and reference to water

1

(c) (i) (Test tube) B

1

(ii) produces bubbles faster
accept more bubbles

or
faster rate of reaction
allow most reactive

1

(d) The particles move faster

1

The particles collide more often

1

[8]

Q12.

(a) (i) 4

1

(ii) (Make) 3

1

biggest <u>temperature</u> <u>rise</u>

1

(b) (i) 1008 (kJ)
*correct answer with or without working gains **2** marks*
*if incorrect answer given allow evidence of 240 × 4.2 for **1** mark*

2

(ii) crisps have a high energy content

allow crisps have lots of calories / kilojoules / fat / one ninth of daily energy intake

1

so if you take in more energy than you need the excess is stored as fat

accept consequences: obesity; heart disease; high blood pressure; diabetes; arthritis

or

crisps contain salt (1)

too much salt can cause high blood pressure **or** heart problems or kidney problems (1)

1

[7]

Q13.

(a) (i) (-)810

ignore sign

*correct answer gains **3** marks with or without working*

*if the answer is incorrect look at the working up to a maximum of **two***

- *bonds broken = (4 × 414) + (2×498) = 2652 kJ*
- *bonds formed = (2x803) + (4x464) = 3462 kJ*
- *correct subtraction of their bonds formed from their bonds broken*

3

(ii) because energy needed to break the bonds

1

is less than the energy released when bonds are formed

1

(b) to provide activation energy

or

to break bonds

1

[6]

Q14.

(a) (i) increase

1

(ii) energy is given out to the surroundings

1

(b) (i) NO

allow 2NO
ignore nitrogen oxide
*do **not** allow equations*

1

(ii) harmful / poisonous (owtte)

allow dangerous
ignore reference to pollution / global warming
*do **not** accept references to ozone layer*

1

(c) a catalyst can speed up a chemical reaction

1

different reactions need different catalysts

1

(d) (i) smaller

accept less / tiny / very small
allow 10^{-9}
*do **not** allow small unless qualified*

1

(ii) reduce cost (owtte) **or**

ignore references to energy

save resources / raw materials (owtte)

1

[8]

Q15.

(a) gives out heat / energy

allow release / loses
allow the products have less energy

or

energy / heat transferred to the surroundings

ignore temperature rises
allow more energy given out in forming bonds than taken in to break bonds

1

(b) (i) speed up the reaction (owtte)

accept changes the rate
accept lowers activation energy
accept increases successful collisions
accept allows reaction to take place at a lower temperature

1

(ii) nitrogen (N_2) / oxygen (O_2) / products are safe **or** not harmful / pollutant /

toxic / dangerous / damaging

ignore releases nitrogen / oxygen unless qualified

or

(harmful) nitrogen monoxide / NO is not released into the air.

accept prevents / less acid rain

ignore greenhouse gas / ozone layer

1

(iii) 2 and 2

accept correct multiples or fractions

1

(iv) idea of catalyst not being used up

allow not changed by reaction

ignore catalyst does not take part

ignore catalyst not used in the reaction

1

(v) idea of different reactions (require different catalysts)

accept catalysts work for specific reactions

allow different gases

1

(c) • smaller / very small / or any indication of very small / 1–100 nanometres / a few (hundred) atoms

ignore just small

ignore size of the converter

1

• big(ger) surface area

1

• less (catalyst) needed / small amount of catalyst needed

1

[9]

Q16.

(a) A = <u>energy</u> / <u>enthalpy</u> change / difference

*allow heat change **or** ΔH*

allow energy released

1

B = activation energy / EA

allow definition of activation energy

1

C = carbon dioxide and water

accept products

1

(b) exothermic

allow combustion / redox / oxidation

ignore reduction / burning

1

[4]

Q17.

(a) *correct answer with or without working = **3** marks*

M1: (bonds broken) = 2148 (kJ)

1

M2: (bonds made) = 2354 (kJ)

1

M3: change in energy
= (-) 206 (kJ)

ecf

ignore sign

1

(b) energy released from forming new bonds is greater than energy needed to break existing bonds

allow the energy needed to break bonds is less than the energy released in forming bonds

*do **not** accept energy needed to form bonds*

1

[4]

Q18.

(a) gives out / releases / transfers to surroundings heat / energy

ignore light / burns

ignore the wire gets hot

1

(b) activation energy

1

(c) (aluminium +) oxygen (→) aluminium oxide

accept correct formulae

1

(d) C

1

(e) (i) a negative

1

(ii) loses

1

(iii) gains

1

two

1

[8]

Q19.

(a) gives out heat / energy

allow more energy given out in making bonds than is used in breaking bonds

or

energy / heat transferred to surroundings

ignore light

1

(b) activation

allow phonetic spelling

1

(c) (i) 2 crosses on inner circle **and**

8 crosses on outer circle

accepts dots / e / – for electrons

1

(ii) opposite charges (attract)

allow electrostatic forces (attract)

*do **not** accept intermolecular attraction / shared electrons*

1

[4]

Q20.

(a) goes up

1

(b) (i) B

1

(ii) A

1

(iii) a catalyst

1

activation energy

1

(c) (i) eg (ensures) complete reaction

allow spread heat / energy

or even heating

allow mixes properly or mix them together or to get correct temperature

ignore dissolves

1

(ii) lid (on beaker)

accept cover beaker

or

insulate (beaker) / use a plastic cup

1

[7]

Q21.

(a) energy released from making (new) bonds is greater than the energy needed to break (existing) bonds

accept the energy needed to break (existing) bonds is less than the energy released in making (new) bonds

*do **not** accept energy needed to make bonds*

1

(b) (i) energy / heat of products less than energy of reactants

accept products are lower than reactants

***or** reactants higher than products*

accept more energy / heat given out than taken in

***or** less energy / heat taken in than given out*

accept energy / heat is given out / lost (to the surroundings)

allow produce heat

ignore produce energy

accept ΔH is negative

***or** energy change / **A** is negative*

or B** is less than **C

1

(ii) **B** is (very) high / large

*it = **B***

*ignore energy change **C** is high*

1

(iii) *it = MnO_2*

(MnO_2) catalyst (is added)

accept it is a catalyst

or reaction catalysed (by MnO_2)

*do **not** accept MgO / magnesium oxide*

1

which lowers activation energy

accept provides alternative / lower energy pathway

or which lowers (energy change) **B**

if hydrogen peroxide is given as a catalyst instead of MnO_2 penalise once only in question

1

(c) any **two** from:

- (chemicals) not mixed / stirred
- heat / energy lost (from apparatus)
- (apparatus) not insulated **or** no lid
- low amount / mass / not enough MnO_2 **or** low concentration H_2O_2
- thermometer read incorrectly

ignore other experimental error

2

[7]

Q22.

(a) (i) 48

1

(ii) 3

1

(b) heat / energy

1

given out / transfers to surroundings

the mark for given out / transfers to cannot be awarded without heat / energy

allow given off

1

(c) it has a low boiling point

1

it is made of small molecules

1

[6]

Q23.

(a) electricity / (high) temperatures

allow lightning / heat

ignore energy

1

(b) nitrogen + oxygen → nitrogen oxide/ monoxide

allow any oxide of nitrogen

1

(c) more than

1

(d) (i) A

1

(ii) C

1

[5]

Q24.

(a) energy of product greater than energy of reactants

allow converse

allow energy = heat

*do **not** accept temperature for energy*

allow product / nitrogen oxide is higher than reactants

allow less energy / heat given out than taken in

allow energy / heat is taken in / gained

allow ∆ H is positive

1

(b) (minimum) energy needed to start the reaction / overcome energy barrier

accept (minimum) energy needed for a collision to be successful

1

(c) (i) *correct answer with or without working= **3** marks*

bonds broken = 945 + 498 = 1443 (kJ)

1

bonds made = 2 × 630 = 1260 (kJ)

1

energy change = 1443 - 1260 = (+) 183

ignore sign

allow ecf

1

(ii) energy released forming new bonds is less than energy needed to break existing bonds owtte

allow converse

accept energy change (∆H) is + / positive

*do **not** accept energy <u>needed to form new bonds</u> is less than energy needed to break existing bonds*

1

[6]

Q25.

(a) (i) (different) properties

allow ideas of different property / behaviour / element

1

(ii) any **one** from:

they = Crawford + Cruikshank

- they had high status

  or

  they were lecturers / doctors / professors / famous scientists

- other scientists repeated experiments
  allow experiment could be repeated
  allow other scientists showed they had different properties

- they had proof

  or

  lots of / strong / conclusive / enough / clear evidence
  ignore evidence unqualified

1

(iii) other scientists obtained similar results / proved it

or

experiments were repeated

1

(b) (i) any **one** from:

- mass of solid / strontium (chloride) / barium (chloride)
  allow amount / volume

- volume of water
  allow amount / mass

- type of container
  allow initial / starting temperature (of water)
  ignore room temperature / time / concentration
  ignore reference to hydrochloric acid

1

(ii) 2 **and** takes in heat / energy

or

2 **and** temperature goes down (owtte)

1

(iii) temperature increased for one experiment and decreased for the other (owtte)

or

one was exothermic and one was endothermic (owtte)
accept experiment 1 was exothermic

1

(c) any **one** from

- positive / + (charge)

  *do **not** accept incorrect further qualification eg electrons / atoms / electrodes*

- opposite (charges) attract

1

[7]

Q26.

(a) (i) increase

1

(ii) high melting point

1

(b) (i) decreases

1

increases

1

(ii) it gives the particles more energy

1

it makes the particles move faster

1

[6]

Q27.

(a) eg plastic (beaker) / insulation / lid / cover **or** any mention of enclosed

any sensible modification to reduce heat loss

ignore prevent draughts

ignore references to gas loss

1

(b) all the substances react **or** all (the substances) react fully / completely **or** heat evolved quickly **or** distribute heat

accept to mix them

'so they react' is insufficient for the mark

accept increase chances of (successful) collisions / collision rate increase

*do **not** accept rate of reaction increase / make reaction faster*

1

(c) experiment 2 **and** different / higher / initial / starting temperature

*accept experiment 2 **and** the room is hotter / at higher temperature*

*do **not** accept temperature change / results higher*

1

(d) temperature change does not fit pattern

*accept anomalous / odd **or** it is the lowest **or** it is lower than the others **or** it is different to the others*

'results are different' is insufficient

1

(e) 7 / 7.0

1

(f) (100 × 4.2 × 7) = 2940

ecf from (e)

1

(g) diagram A **and** reaction exothermic / heat evolved / Δ H is negative / temperature rises

accept energy is lost (to the surroundings)

1

[7]

Q28.

(a) carbon dioxide

must be name

*do **not** accept carbon oxide*

1

(b) (i) the temperature of the solution will decrease

(list principle)

1

(ii) energy is taken in from the surroundings

(list principle)

1

[3]

Q29.

(a) hydrogen + oxygen → water

accept $2H_2 + O_2 \rightarrow 2H_2O$ or balanced multiples or fractions
allow 1 or 2 correct formulae substituted for words
*allow hydrogen oxide **or** steam for water*

1

(b) supplied

released

both needed, must be in this order

1

(c) (i) B

1

(ii) A

1

(iii) to overcome activation energy to react **or** (activation) energy needed to start reaction

allow to provide energy

1

[5]

Q30.

(a) (bonds broken) = 1370 (kJ)

1

(bonds made) = 1856 (kJ)

1

change in energy = (–) 486

ecf
ignore sign
*correct answer with **or** without working = **3** marks*

1

(b) energy released from forming new bonds is greater than the energy needed to break existing bonds

allow the energy needed to break bonds is less than the energy released in forming bonds
*do **not** accept energy needed to form bonds*

1

(c) (i) energy barrier needs to be overcome

or

activation energy supplied / needed

*allow energy needed to start reaction **or** energy needed to break bonds*
accept high activation energy

1

(ii) lowers activation energy(*)

or

provides lower energy pathway / route(*)

*(*)**2** mark answers*
*allow provides alternative pathway **or** platinum / it is a catalyst for **1** mark*

2

[7]

Q31.

(a) gives out (heat)

1

(b) D

1

(c) L

1

(d) magnesium chloride

1

[4]

Q32.

(a) either:
calculations: all correct (ethanol = 6, methanol = 3,
peanut oil = 10, vegetable oil = 15)

ignore repetition of data from table unqualified

or

implication of correct calculation

(vegetable oil) gives largest temperature / heat increase <u>per gram</u> (owtte)

allow 'produced most heat in proportion to the fuel used'
*owtte for **1** mark*

2

(b) any **one** from:

owtte

- smoke

ignore references to crops/food

- soot
- carbon
- carbon monoxide
- carbon dioxide
- global warming / climate change / greenhouse gases
- (air) pollution
- harmful/poisonous

1

scrub / wash the gases owtte

filter / remove (gases / fumes / appropriate named substance) owtte

(add extra oxygen) can burn more efficiently owtte

use a cleaner fuel owtte
plant more trees or similar linked to CO_2
any sensible answer
'don't burn so much fuel' insufficient alone
ignore extractor fans / air conditioning

1

(c) (i) A

1

(ii) B

1

[6]

Q33.

(a) the bag gets cold because heat energy is taken in from the surroundings

1

(b) endothermic

1

(c) any **two** from:

- mix / spread (the ammonium nitrate and water)
- dissolve faster(*)
- get cold faster **or** so the whole bag gets cold(*)
  *(*)allow increase rate **or** quicker reaction*
- particles collide more **or** more collisions

2

[4]

Q34.

(a) (i) floated / (moved on) surface
accept does not sink
ignore it melted

1

(ii) melted / molten
ignore heat is given off

1

(iii) hydrogen
allow H_2

1

(b) (i) potassium / rubidium / caesium / francium
accept: K / Rb / Cs / Fr

1

(ii) they are metals

1

they form ions with a 1+ charge

1

(c) (i) atomic weight

1

(ii) similar

1

(iii) groups

1

(d) left gaps owtte

1

[10]

Q35.

(a) endothermic **and** because it takes in heat / energy

both *for one mark*

1

(b) (i) reversible reaction (or explanation)

1

(ii) add water

do ***not*** *accept cooling* ***or*** *reverse the reaction*

1

[3]

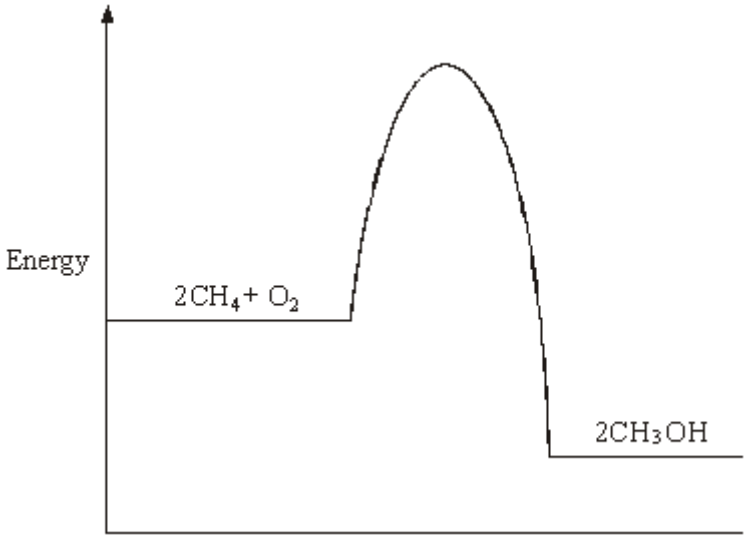
Q1.

Methanol (CH_3OH) can be made by reacting methane (CH_4) and oxygen (O_2) in the presence of a platinum catalyst. The reaction is exothermic.

An equation that represents the reaction is:

$$2CH_4 + O_2 \rightarrow 2CH_3OH$$

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



(i) Use the diagram to explain how you know that this reaction is exothermic.

_____

_____

_____

(1)

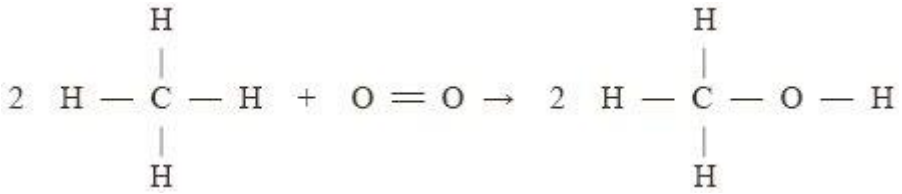
(ii) Explain, in terms of the energy level diagram, how the platinum catalyst increases the rate of this reaction.

_____

_____

(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
C — H	435
O = O	498
C — O	805

O — H	464

Energy change = _____ kJ

(3)

(ii) In terms of the bond energies, explain why this reaction is exothermic.

(1)

(Total 6 marks)

Q2.

The reaction of methane with steam is used in industry to make hydrogen.

(a) One of the reactions in this process is represented by this equation.

CH_4 (g) + H_2O ⇌ CO (g) + $3H_2$ (g)

The forward reaction is endothermic.

State the conditions of temperature and pressure that would give the maximum yield of hydrogen.

Explain your answers.

(i) Temperature

(2)

(ii) Pressure

(2)

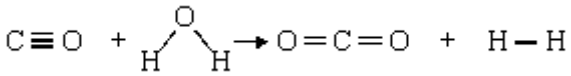
(iii) Which one of the following metals is most likely to be a catalyst for this process? Draw a ring around your answer.

aluminium **lead** **magnesium** **nickel** **sodium**

Give a reason for your choice.

(1)

(b) A second stage in this process is represented by this equation.



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

Bond	Bond energy in kJ/mol
C ≡ O	1077
C = O	805
H – H	436
O – H	464

Nett energy transfer = _____ kJ/mol

(3)

(ii) State whether this reaction is exothermic or endothermic. _____

Explain, by reference to your calculation, how you know.

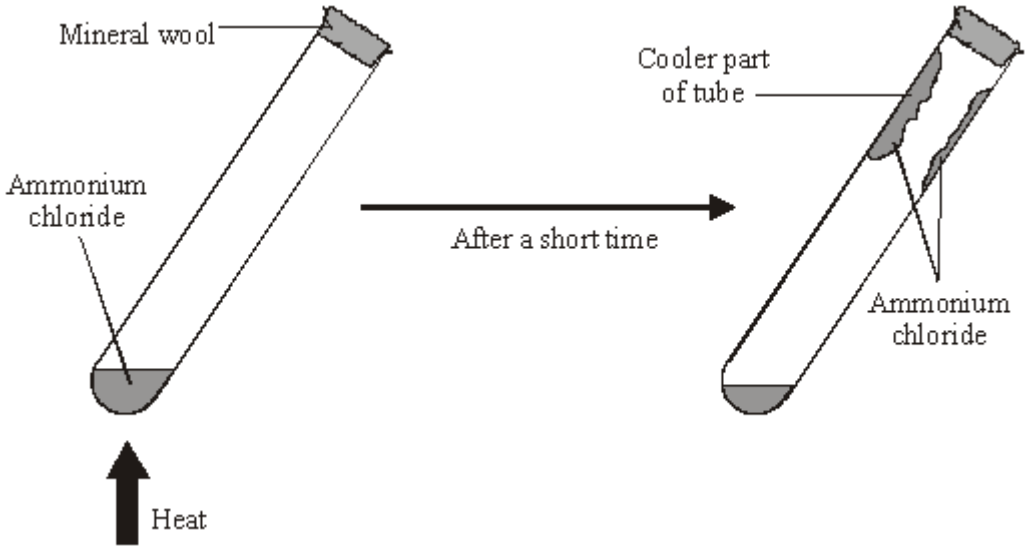
(2)

(Total 10 marks)

Q3.

A student did two experiments using ammonium chloride.

(a) In the first experiment the student heated a small amount of ammonium chloride in a test tube.



Two reactions take place in the test tube.

Reaction **1**	ammonium chloride → ammonia + hydrogen chloride (colourless gases)
Reaction **2**	ammonia + hydrogen chloride → ammonium chloride

(i) Complete the sentences by crossing out the **incorrect** word in each box.

Reaction **1** takes place at a [high / low] temperature.

Reaction **2** takes place at a [high / low] temperature.

(1)

(ii) Draw a ring around the word which best describes reactions **1** and **2**.

combustion displacement oxidation reduction reversible

(1)

(iii) Suggest a reason for the mineral wool at the top of the test tube.

_____

_____

(1)

(b) In the second experiment the student mixed a small amount of ammonium chloride with some water in a beaker.

The temperature of the water was measured before and after adding the ammonium chloride.

Temperature before adding the ammonium chloride	20°C
Temperature after adding the ammonium chloride	16°C

Draw a ring around the word which best describes the process which takes place.

combustion displacement endothermic exothermic freezing

(1)

(Total 4 marks)

Q4.

Silicon is an important element used in the electronics industry.

(a) Silicon can be made by heating a mixture of sand (silicon dioxide) with magnesium powder.

The equation for this reaction is shown below.

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

Calculate the mass of silicon dioxide needed to make 1 g of silicon.

Relative atomic masses: O = 16; Si = 28

_____

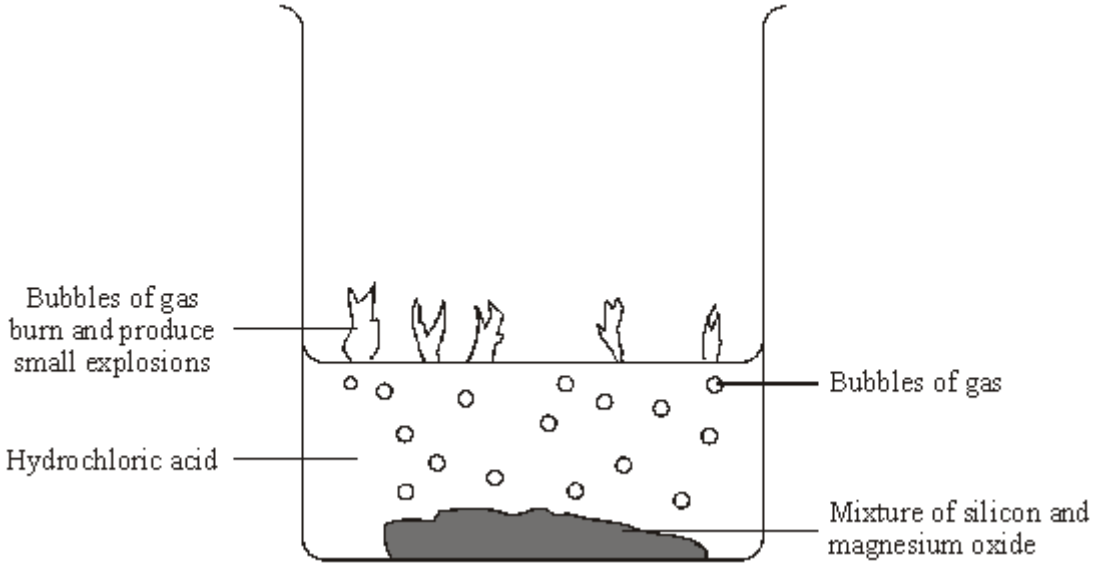
_____

_____

Mass = _____ g

(3)

(b) The resulting mixture of magnesium oxide and silicon is added to a beaker containing hydrochloric acid. The silicon is then filtered from the solution.



(i) The magnesium oxide reacts with the hydrochloric acid and forms magnesium chloride ($MgCl_2$) solution and water.

magnesium oxide + hydrochloric acid → magnesium chloride solution + water

Write a balanced symbol equation for this reaction, including state symbols.

(2)

(ii) The gases produced are a mixture of several silicon hydrides.

One of the gases produced in the reaction is the silicon hydride with the formula SiH_4. The structure of this molecule is similar to methane, CH_4.

Draw a diagram to show the bonding in a molecule of SiH_4. Represent the electrons as dots and crosses and only show the outer shell (energy level) electrons.

(1)

(iii) A sample of a different silicon hydride was found to contain 1.4 g of silicon and 0.15 g of hydrogen.

Calculate the formula of this silicon hydride. You must show all your working to gain full marks.

Relative atomic masses: H = 1; Si = 28

(4)

(iv) The silicon hydrides react immediately they come into contact with oxygen in the air. They burst into flames with a small explosion and give out energy.

Which letter, **A** to **H**, best describes this reaction?

Energy involved in breaking and forming bonds	Activation energy	Rate of reaction	Letter
The energy released from forming new bonds is greater than the energy needed to break existing bonds	high	fast	**A**
		slow	**B**
	low	fast	**C**
		slow	**D**
The energy needed to break existing bonds is greater than the energy released from forming new bonds	high	fast	**E**
		slow	**F**
	low	fast	**G**
		slow	**H**

Letter _____

(1)

(c) The structure of silicon is similar to the structure of diamond.

Describe the structure of silicon and explain why it has a high melting point. You may draw a diagram if this helps.

(4)

(Total 15 marks)

Q5.

A student investigated some instant soup.

(a) Instant soup contains a food additive which has the formula:

NaH_2PO_4

Give the names of all the elements in this compound.

The periodic table on the Data Sheet may help you to answer this question.

(2)

(b) The student investigated the reaction which takes place when soup powder is added to cold water.

The student thought that the reaction might be *exothermic.*

(i) What is meant by the term *exothermic* reaction?

(2)

(ii) Describe an experiment that the student could do to prove that this reaction is exothermic.

To gain full marks in this question you should write your ideas in good English. Put them into a sensible order and use the correct scientific words.

_____

_____

_____

_____

_____

_____

(4)

(Total 8 marks)

Q6.

The monomer chloroethene is made from ethene in a two-stage process,

(a) The first stage is to convert ethene to 1,2-dichloroethane.

$$2C_2H_4(g) + 4HC1(g) + O_2(g) \rightleftharpoons 2C_2H_4Cl_2(g) + 2H_2O(g)$$

ethene 1,2-dichloroethane

State and explain the effect of increasing the pressure on:

(i) the yield of 1,2-dichloroethane;

_____

_____

(2)

(ii) the rate of reaction.

_____

_____

(2)

(b) In the second stage 1,2-dichloroethane is converted into chloroethene.

$C_2H_4C1_2 \rightarrow C_2H_3C1 + HCl$

This reaction is a thermal decomposition.

Suggest what would need to be done to decompose 1,2-dichloroethane.

_____

_____

(1)

(Total 5 marks)

Q7.

Some of the hydrogen and chlorine are reacted together to form hydrogen chloride.

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

Bond	Bond energy in kJ/mol
Cl–Cl	242
H–Cl	431
H–H	436

(i) Use the bond energies to calculate the energy change for the formation of hydrogen chloride.

Energy change = _____ kJ/mol

(3)

(ii) Is this reaction exothermic or endothermic? Explain your answer.

(2)

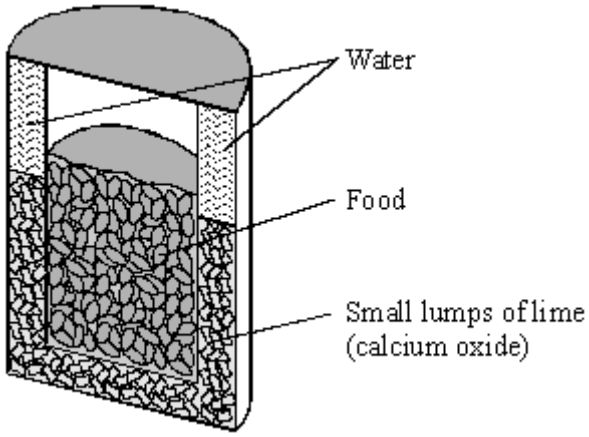
(iii) Explain why hydrogen chloride only acts as an acid when dissolved in water.

(3)

(Total 8 marks)

Q8.

Mountaineers can warm their food in self-heating, sealed containers.



(a) The water is allowed to react with the lime. The heat from the reaction warms the food. What type of reaction causes a rise in temperature?

_____

(1)

(b) Some students investigated the effect of adding different sized lumps of lime to water. The results of their investigation are shown.

Time in minutes	Temperature in °C		
	Large lumps of lime	Small lumps of lime	Powdered lime
0	18	18	18
1	19	20	28
2	21	23	43
3	24	27	63
4	28	32	88
5	33	38	100

What do these results show? Give an explanation for your answer.

_____

_____

_____

_____

(2)

(c) Suggest and explain **one** disadvantage of using powdered lime to heat food.

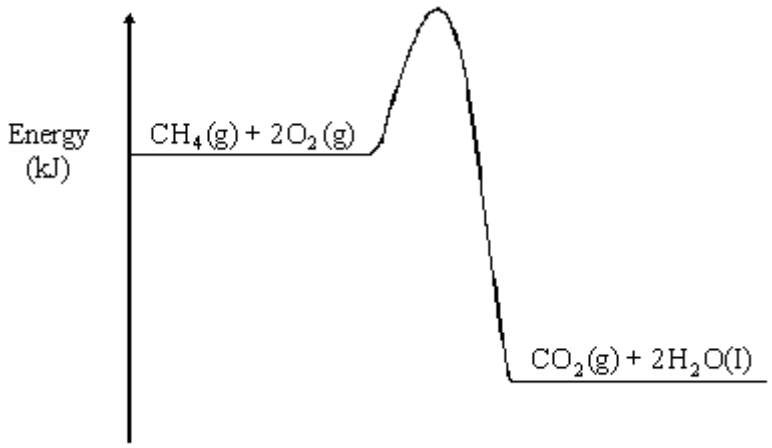
_____

(2)

(Total 5 marks)

Q9.

Many hydrocarbons are used as fuels. An energy level diagram is shown for the combustion of the hydrocarbon methane.



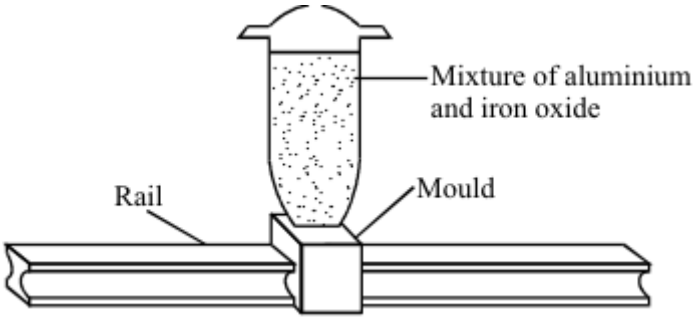
Describe and explain why the line rises and then falls to a lower level.

(Total 4 marks)

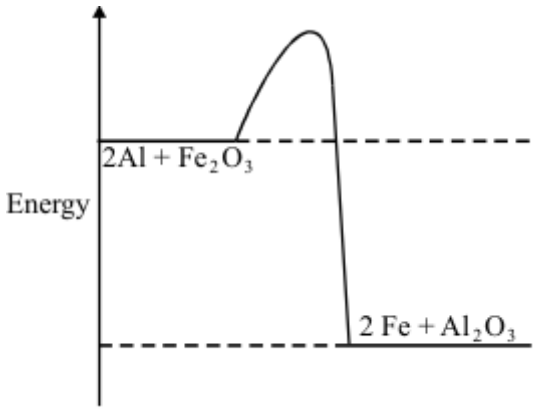
Q10.

The reaction between aluminium and iron oxide is used to weld together railway lines.

$$2Al(s) + Fe_2O_3(s) \rightarrow 2Fe(l) + Al_2O_3(s)$$



A simple, qualitative energy level diagram for this reaction is shown.



Use the energy level diagram to:

(i) describe the idea of activation energy;

_____

_____

(1)

(ii) explain why the reaction produces molten iron.

_____

_____

_____

_____

(2)

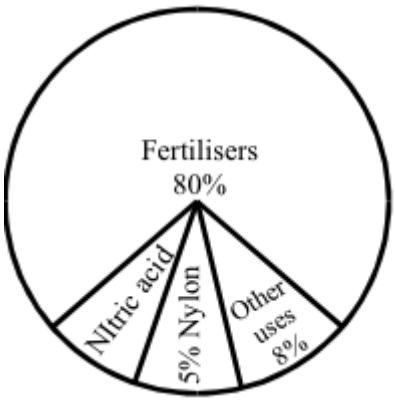
(Total 3 marks)

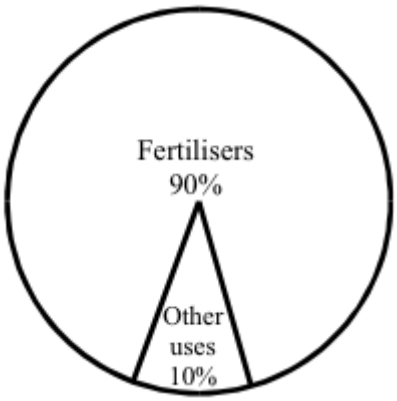
Q11.

Ammonia and nitric acid are both important chemicals. Nitric acid is made from ammonia.

The charts below show substances made from ammonia and nitric acid.

Substances made from ammonia	Substances made from nitric acid





(a) Use the charts to help you answer these questions.

(i) What is the main use of both ammonia and nitric acid?

_____

(1)

(ii) Work out the percentage of ammonia used to make nitric acid.

Percentage = _____ %

(1)

(iii) 100 million tonnes of ammonia are made in the world each year.

How much of this ammonia is used to make nylon?

_____ million tonnes

(1)

(b) The word equations below show how nitric acid is made.

1. nitrogen + hydrogen → ammonia
2. ammonia + oxygen → nitrogen monoxide + water
3. nitrogen monoxide + oxygen → nitrogen dioxide
4. nitrogen dioxide + water → nitric acid

Use the word equations to help you answer these questions.

(i) From which **two** elements is ammonia made?

_____ and _____

(1)

(ii) Name **two** of the raw materials needed to make nitric acid.

_____ and _____

(2)

(c) A large amount of nitric acid is reacted with ammonia to make a fertiliser.

nitric acid + ammonia → fertiliser

(i) The reaction is a neutralisation reaction.

What type of chemical must ammonia be?

_____

(1)

(ii) Complete the chemical name for the fertiliser made from ammonia and nitric acid.

ammonium _____

(1)

(iii) The reaction of nitric acid with ammonia is exothermic.

Name the piece of equipment you could put into the solution to prove that the reaction is exothermic.

_____

(1)

(Total 9 marks)

Q12.

The word equation below shows a reaction used in an industrial process.

chromium oxide + aluminium → chromium + aluminium oxide

The reaction is highly exothermic.

(a) What is an exothermic reaction?

_____

_____

(2)

(b) Name the products of this reaction.

_____

(1)

(c) In the reaction one substance is reduced.

(i) Name the substance which is reduced.

_____

(1)

(ii) What happens to the substance when it is reduced?

_____

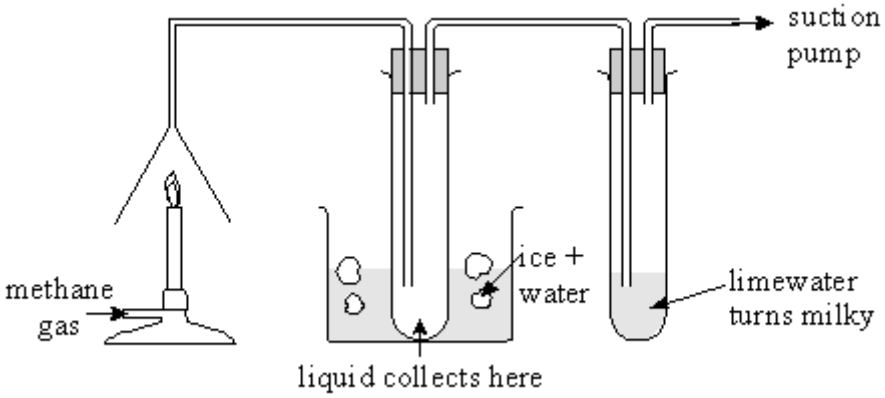
_____

(1)

(Total 5 marks)

Q13.

Methane CH_4 contains the elements carbon and hydrogen only. A student wanted to find out which new substances are produced when methane is burned. The student set up the apparatus shown below.



(a) Which gas in the air reacts with methane when it burns?

_____

(1)

(b) Name the liquid collected.

_____

(1)

(c) Name the gas which turns limewater milky.

_____

(1)

(d) When methane burns an exothermic reaction takes place. What is meant by an exothermic reaction?

_____

_____

(2)

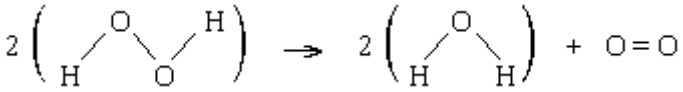
(Total 5 marks)

Q14.

At room temperature, hydrogen peroxide decomposes very slowly to form water and oxygen.
The decomposition is speeded up when a catalyst is added.

(a) The following equation represents the decomposition of hydrogen peroxide.

The structural formulae of the chemicals involved are shown.



Use the following information about bond energies to answer this part of the question.

BOND	BOND ENERGY (kJ)
O = O	498
O – O	146
H – O	464

(i) Calculate the energy needed to break all the bonds in the reactants.

_____

_____

_____

_____ kJ

(2)

(ii) Calculate the energy released when new bonds are formed in the products.

_____

_____

_____

_____ kJ

(2)

(iii) Calculate the energy change for this reaction.

_____

_____ kJ

(1)

(iv) Is the reaction exothermic or endothermic?

_____

Explain why.

_____

_____

(1)

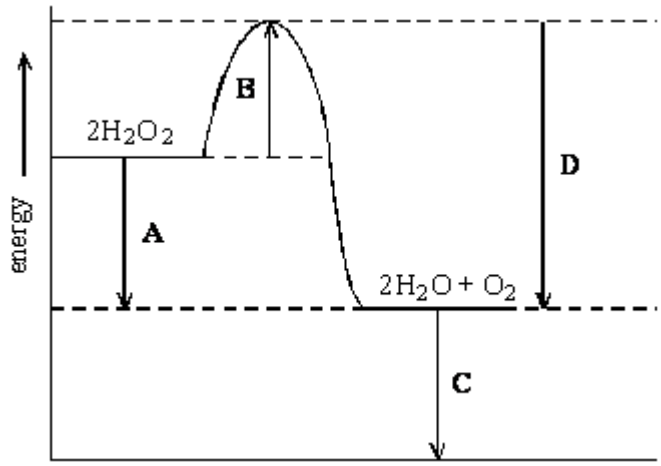
(b) (i) What is meant by 'activation energy'?

_____

_____

(1)

(ii) The energy level diagram for the decomposition of hydrogen peroxide into water and oxygen is shown below.



Which energy change, **A**, **B**, **C** or **D**, is the activation energy? _____

(1)

(iii) Explain, in terms of energy, how a catalyst makes hydrogen peroxide decompose more quickly.

_____

_____

_____

(1)

(Total 9 marks)

Q15.

(i) Which acid from the list should the student add to sodium hydroxide solution to make sodium sulphate?

ethanoic acid **hydrochloric acid** **nitric acid** **sulphuric acid**

_____

(1)

(ii) When the acid was added to the alkali the beaker became warm.
Name the type of reaction that releases heat.

_____

(1)

(iii) Use the Data Sheet to help you to write the formula of sodium sulphate.

Formula: _____

(1)

(Total 3 marks)

Q16.

(a) (i) Which acid should the student add to sodium hydroxide solution to make sodium sulphate?

_____ acid

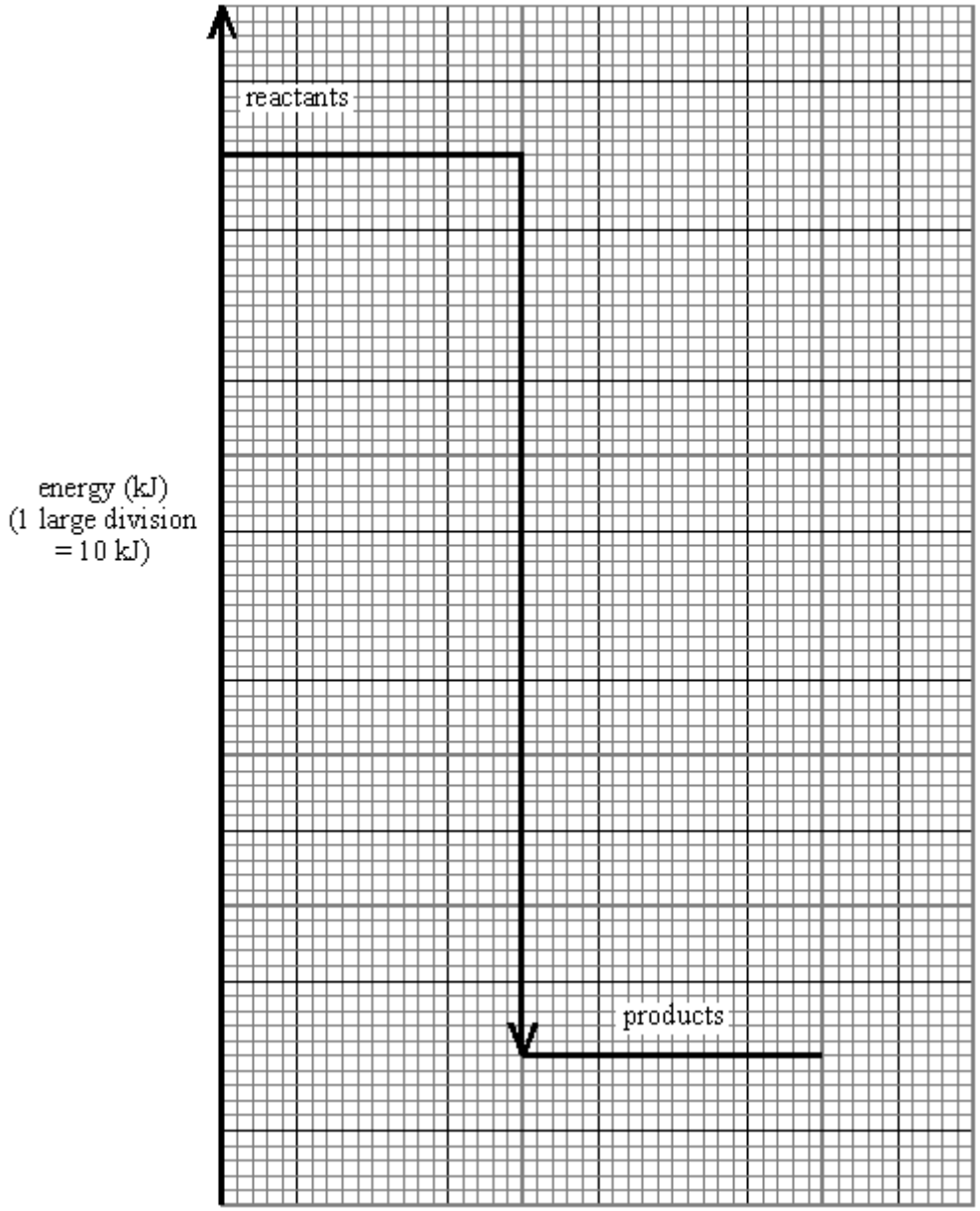
(1)

(ii) Use the table on the Data Sheet to help you to write the formula of sodium sulphate.

Formula: _____

(1)

(b) The student noticed that the solution in the beaker got warm when the acid reacted with the alkali.
The energy diagram below represents this reaction.



(i) In terms of **energy**, what type of reaction is this?

_____

(1)

(ii) Use the energy diagram to calculate a value for the amount of energy released during this reaction.

_____

Energy released _____ kJ

(1)

(iii) Explain, in terms of bond breaking and bond forming, why energy is released during this reaction.

_____

(3)

(iv) The reaction takes place very quickly, without the help of a catalyst. What does this suggest about the activation energy for this reaction?

(1)

(Total 8 marks)

Q17.

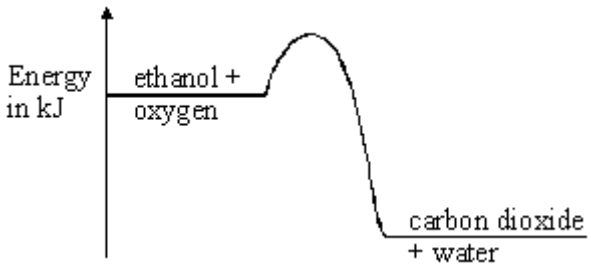
Ethanol is used as a fuel.

(a) Balance the symbol equation for the combustion reaction.

$$C_2H_5OH + O_2 \rightarrow CO_2 + H_2O$$

(1)

(b) The energy level diagram represents the combustion of ethanol.



Describe what must happen to the molecules of ethanol and oxygen to allow them to react.

(3)

(c) We can use bond energies to calculate the energy change for the reaction between hydrogen and oxygen.

$2H_2 + O_2 \rightarrow 2H_2O$

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

(i) Calculate the total bond energy of the reactants.

Total bond energy of reactants = _____ kJ

(2)

(ii) Is the reaction between hydrogen and oxygen exothermic or endothermic? Use bond energies to explain your answer.

(2)

(Total 8 marks)

Q18.

Hydrogen chloride is made by reacting hydrogen with chlorine.

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

Bond	Bond energy in kJ
H – H	436
Cl – Cl	242
H – Cl	431

Is the reaction between hydrogen and chlorine exothermic or endothermic?
Use the bond energies to explain your answer.

(Total 3 marks)

Q19.

In the Haber process, nitrogen and hydrogen react to make ammonia.

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

nitrogen + hydrogen $\rightleftharpoons$ ammonia

Pressure in atmospheres	% ammonia present at equilibrium				
	Temperature in ºC				
	100	**200**	**300**	**400**	**500**
10	88.2	50.7	14.7	3.9	1.2
25	91.7	63.6	27.4	8.7	2.9
50	94.5	74.0	39.5	15.3	5.6
100	96.7	81.7	52.5	25.2	10.6
200	98.4	89.0	66.7	38.8	18.3
400	99.4	94.6	79.7	55.4	31.9
1000	99.9	98.3	92.6	79.8	57.5

The actual conditions used in the Haber process are usually 450 °C and 200

atmospheres.

(a) What effect does increasing the pressure have on the percentage of ammonia made? Use the balanced symbol equation to explain why.

(2)

(b) A lower temperature of 100 °C gives high percentages of ammonia at most pressures. Why is this temperature **not** used in the Haber process?

(1)

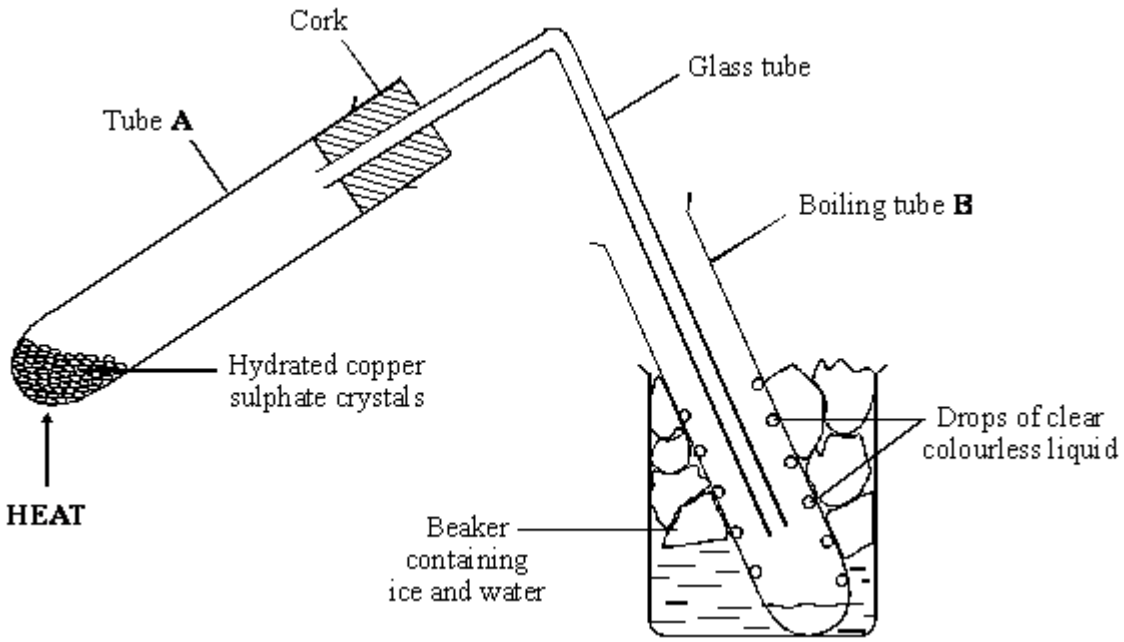
(c) Describe and explain the effect of an increase in the temperature on the reaction between nitrogen and hydrogen in the Haber process.

(3)

(Total 6 marks)

Q20.

The diagram shows the apparatus for an experiment. Hydrated copper sulphate crystals were heated. They became anhydrous copper sulphate.



(a) Name a suitable piece of equipment to heat tube **A**.

_____

(1)

(b) Use words from the box to complete the **two** spaces in the table. You may use each word once or not at all.

black	blue	orange	red	purple	white

Name	Colour
Hydrated copper sulphate crystals	_____
Anhydrous copper sulphate	_____

(2)

(c) What is the purpose of the ice and water in the beaker?

_____

_____

(1)

(d) Drops of a clear, colourless liquid formed on the inside of tube **B**.

(i) Name the liquid.

_____

(1)

(ii) Explain how the liquid came to be inside tube **B**.

_____

_____

_____

(2)

(e) Anhydrous copper sulphate can be turned into hydrated copper sulphate. What would you need to add? Apart from the change in colour, what could you observe?

_____

_____

_____

(2)

(f) Copper sulphate can be made from black copper oxide by reacting it with an acid. Name the acid.

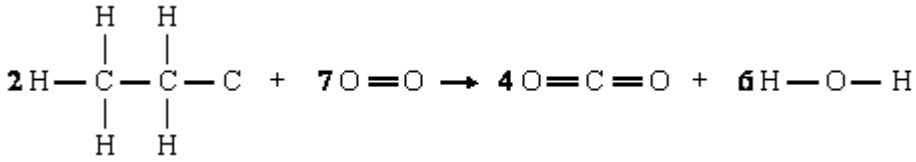
_____

(1)

(Total 10 marks)

Q21.

The balanced equation for the combustion of ethane is shown using structural formulae.



(a) Complete the table to show the number of bonds broken and made when two molecules of ethane react with seven molecules of oxygen.

Type of bond	Number of bonds broken	Number of bonds made
C — C		
C — H		
O = O		
C = O		
H — O		

(2)

(b) The combustion of ethane is a strongly exothermic process. Draw a labelled energy level diagram showing the endothermic and exothermic parts of the overall reaction. Indicate the activation energy on the diagram.

(4)

(c) Explain, in terms of particles and the activation energy of a reaction, how a catalyst is able to increase the rate of reaction.

_____

_____

_____

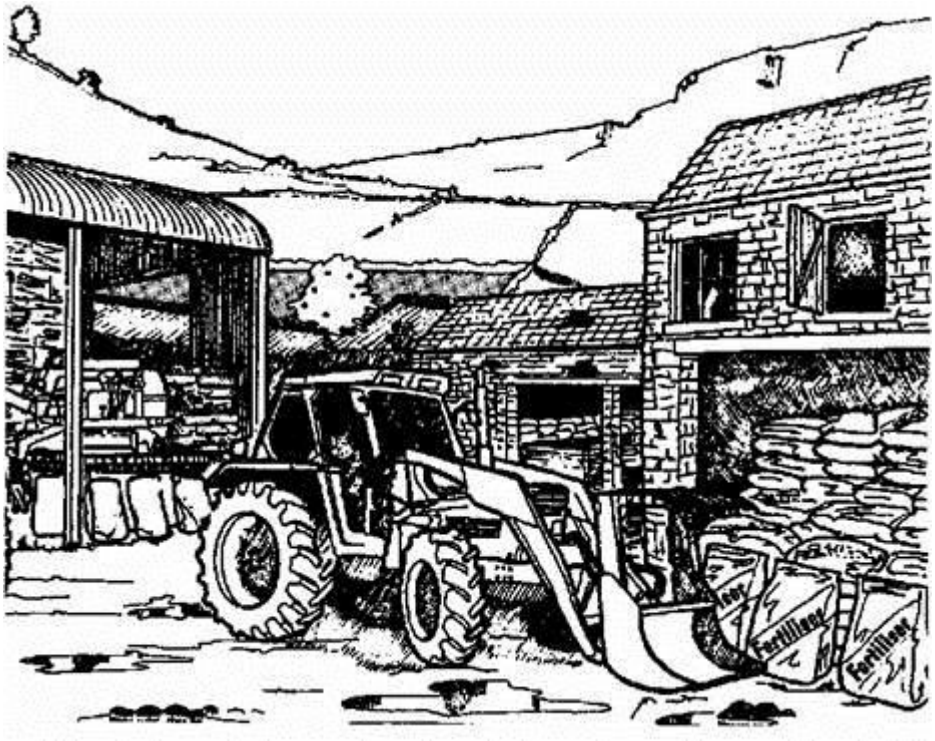
_____

(2)

(Total 8 marks)

Q22.

Ammonium nitrate and ammonium sulphate are used as fertilisers.



(i) Which acid reacts with ammonia to form ammonium nitrate?

_____

(1)

(ii) Which acid reacts with ammonia to form ammonium sulphate?

_____

(1)

(iii) The reactions in (i) and (ii) are both exothermic. How can you tell that a reaction is exothermic?

_____

_____

(1)

(iv) The reactions in (i) and (ii) are both examples of acid + base reactions. What is the name of the chemical change which takes place in every acid + base reaction?

_____

(1)

(Total 4 marks)

Q23.

Wax is a fuel.

A young child watched a candle burning and wondered where the wax had gone.

(a) Complete the sentence below.

When wax burns, energy is released as _____

(1)

(b) Why does the wax disappear as it burns?

_____

_____

(1)

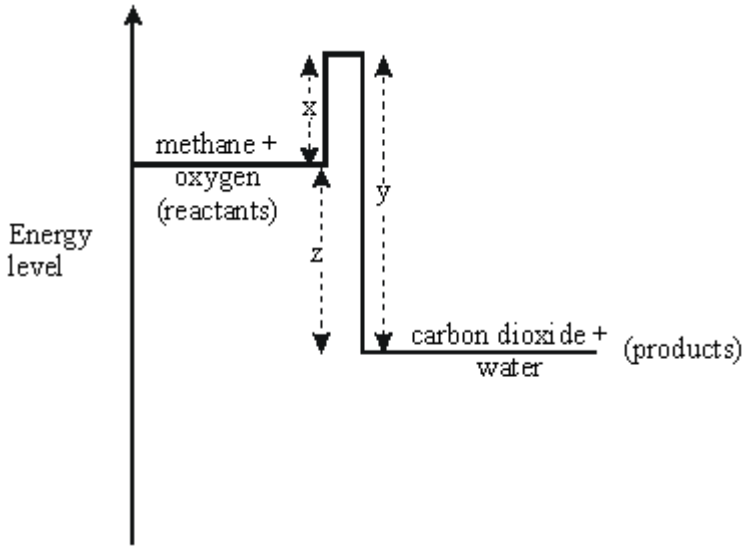
(Total 2 marks)

Q24.

The symbol equation below shows the reaction when methane burns in oxygen.

$CH_4 + 2O_2 \rightarrow CO_2 + 2H_2O$

An energy level diagram for this reaction is shown below.



(a) Which chemical bonds are broken and which are formed during this reaction?

(4)

(b) Explain the significance of x, y and z on the energy level diagram in terms of the energy transfers which occur when these chemical bonds are broken and formed.

(5)

(Total 9 marks)

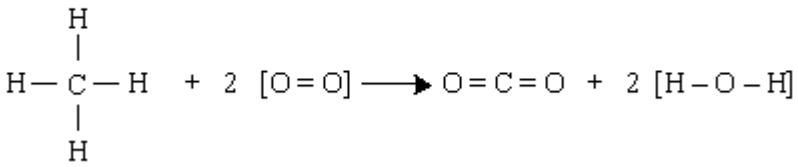
Q25.

The symbol equation shows the reaction between methane and oxygen.

$$CH_4 + 2O_2 \rightarrow CO_2 + 2H_2O$$

methane oxygen carbon dioxide water

The structural formulae in the equation below show the bonds in each molecule involved.



In the three stages shown at (i), (ii) and (iii) below, calculate the net energy transfer when the formula mass (1 mole) of methane reacts with oxygen.

(i) Write down the bonds broken and the bonds formed during the reaction.

Bonds broken		**Bonds formed**	
number	**type**	**number**	**type**

(4)

(ii) Calculate the total energy changes involved in breaking and in forming each of these bonds.

Total energy change in breaking bonds	**Total energy change in forming bonds**

(4)

(iii) Describe, as fully as you can, what the above figures in (ii) tell you about the overall reaction.

_____

_____

_____

_____

(2)

(Total 10 marks)

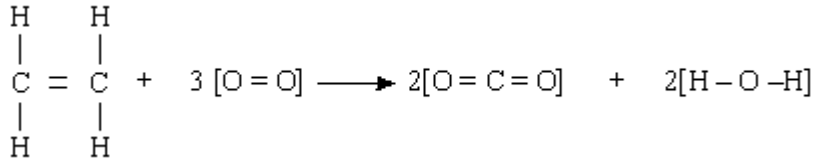
Q26.

You will find the information on the Data Sheet helpful when answering this question.

This equation shows the reaction between ethene and oxygen.

$C_2H_4 + 3O_2 \rightarrow 2CO_2 + 2H_2O$

The structural formulae in the equation below show the bonds in each molecule involved.



Use the three stages shown at (a), (b) and (c) below to calculate the nett energy transfer when the formula mass (1 mole) of ethene reacts with oxygen.

(a) Write down the bonds broken and the bonds formed during the reaction. (Some have already been done for you.)

Bonds broken	
Number	Type
4	[C – H]
1	[C = C]

Bonds formed	
Number	Type
4	[C = O]

(2)

(b) Calculate the total energy changes involved in breaking and in forming all of these bonds. (Some have already been done for you.)

Total energy change in breaking bonds
[4 × 413] = 1652
[1 × 612] = 612
Total = kJ

Total energy change in forming bonds
4 × [805] = 3220
Total = kJ

(4)

(c) Describe, as fully as you can, what the figures in (b) tell you about the overall reaction.

_____

_____

_____

_____

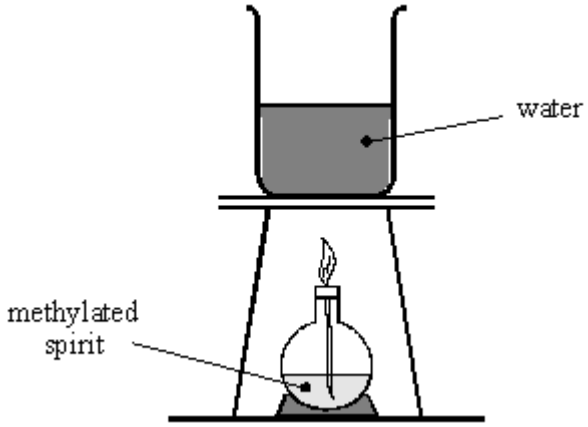
_____

(2)

(Total 8 marks)

Q27.

A student is using a spirit burner to heat some water.



(a) Complete these sentences.

Substances like methylated spirit which we burn to give out energy, are called

_____ . The energy is given out as _____ energy.

(2)

(b) Choose a word from this list to complete the sentence below.

gases **liquids** **solids**

The methylated spirit seems to disappear as it burns.

The new substances produced during burning are mainly _____.

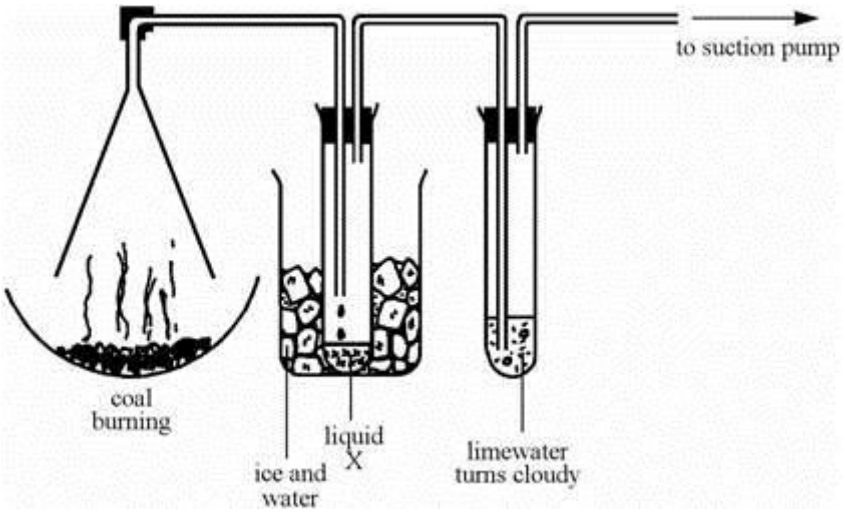
(1)

(Total 3 marks)

Q28.

The gases produced when coal burns are cooled by ice and then bubbled through

limewater.



(a) Complete these sentences.

(i) The coal is reacting with _____ when it burns.

(ii) During burning, elements in the coal are converted to compounds called _____.

(2)

(b) Choose words from this list to complete the sentences.

carbon **carbon dioxide** **sulphur** **sulphur dioxide**

sodium **water**

(i) Liquid X is a compound made from hydrogen and oxygen.

It is called _____

(ii) Sulphur dioxide is an acidic gas. It is given off when coal burns, because coal contains the element _____

(iii) Most fuels are compounds of hydrogen and _____

(3)

(c) Burning coal is an exothermic reaction.

Explain what “exothermic” means.

_____

_____

(1)

(d) (i) Which gas turns limewater cloudy?

_____

(ii) Which element in the coal is oxidised to form this gas?

_____

(2)

(Total 8 marks)

Q29.

Choose words from this list to complete the sentences,

ammonia	**carbon dioxide**	**hydrogen**	**nitrogen**
electrical	**heat**	**solar**	**sound**

(a) In air, the two most common gases are oxygen and _____ .

(b) When natural gas burns, energy is released mainly as _____ .

(c) When natural gas burns, a gas is produced which turns limewater milky.

The gas is _____ .

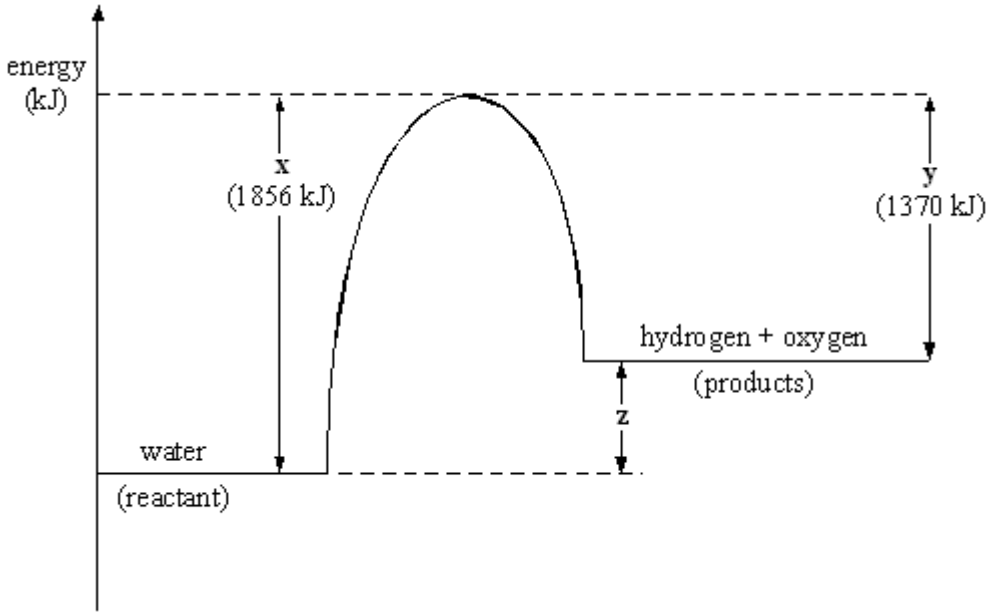
(Total 3 marks)

Q30.

The symbol equation shows the decomposition of water.

$2H_2O \rightarrow 2H_2 + O_2$

An energy level diagram for this reaction is shown below.



Explain the significance of **x**, **y** and **z** on the energy level diagram in terms of energy transfers that occur in the reaction. You should make specific reference to the bonds broken and formed and to the nett energy transfer (energy transferred to or from the surroundings).

_____

_____

_____

_____

_____

_____

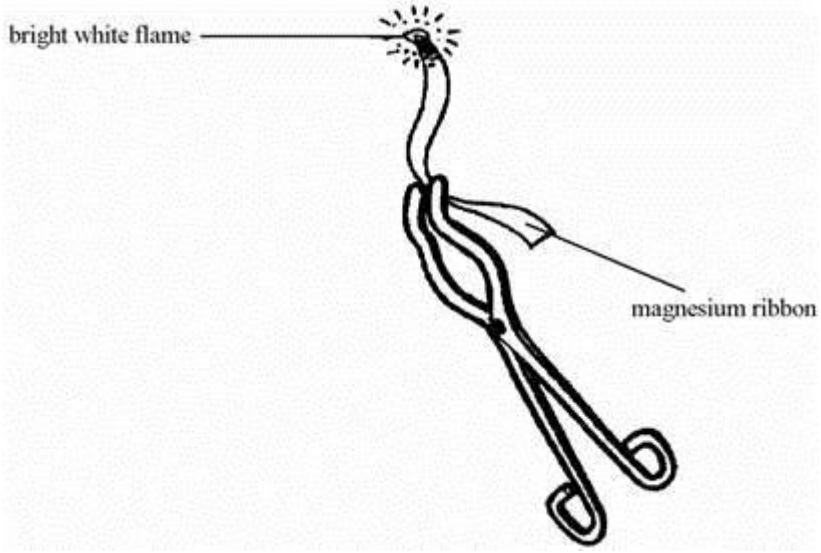
_____

_____

(Total 6 marks)

Q31.

The diagram shows some magnesium ribbon burning.



(a) Choose words from the list to complete the sentences below.

electrical	**heat**	**light**	**kinetic**
an endothermic	**an exothermic**	**a neutralisation**	**a reduction**

When magnesium burns, it transfers _____

and _____ energy to the surroundings.

We say that it is _____ reaction.

(3)

(b) Complete the word equation for the reaction.

magnesium + _____ ⟶ magnesium oxide

(1)

(Total 4 marks)

Q32.

Methane and oxygen react together to produce carbon dioxide and water.

$CH_4 + 2O_2 \longrightarrow CO_2 + 2H_2O$

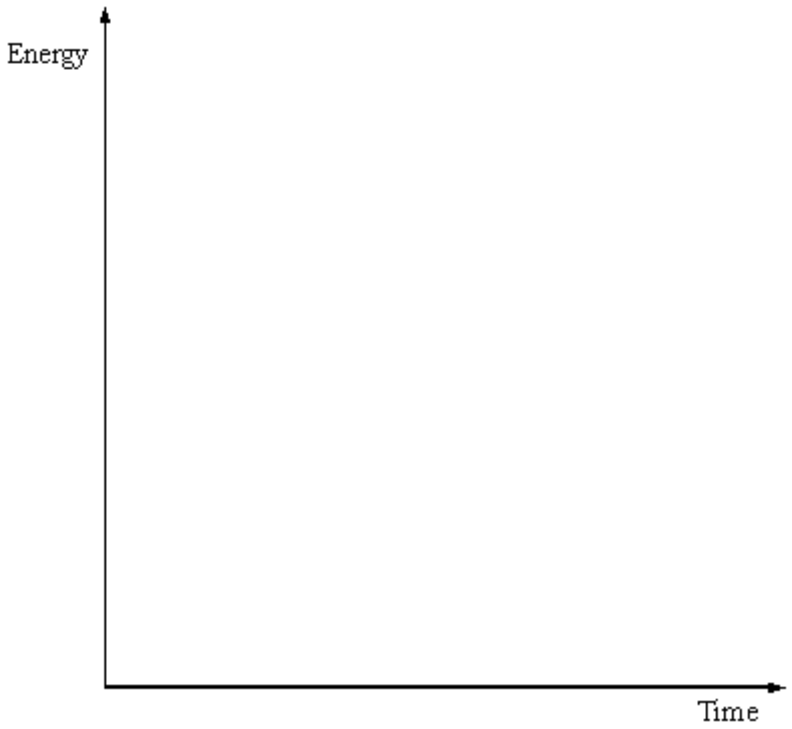
818 kJ of energy is given out to the surroundings for each formula mass (mole) of methane that reacts.

The methane gas will not burn in oxygen until a flame is applied, but once lit it continues to burn.

(a) Explain why energy must be supplied to start the reaction but it continues by itself once started.

(4)

(b) Sketch an energy level diagram for the reaction and indicate on the diagram the nett energy released.



(3)

(Total 7 marks)

Mark schemes

Q1.

(a) (i) energy / heat of products less than energy of reactants

owtte

allow products are lower than reactants

allow more energy / heat given out than taken in

allow methanol is lower

allow converse

allow energy / heat is given out / lost allow ΔH is negative

1

(ii) lowers / less activation energy

owtte

allow lowers energy needed for reaction

***or** it lowers the peak/ maximum*

*do **not** allow just 'lowers the energy'*

1

(b) (i) bonds broken: (2 × 435) + 498 = 1368

allow: (8 × 435) + 498 = 3978

1

bonds made: (2 × 805) + (2 × 464) = 2538

allow: (6 × 435) + (2 × 805) + (2 × 464) = 5148

1

energy change: 1368 – 2538 = (–)1170

allow: 3978 – 5148 = (–)1170

ignore sign

allow ecf

*correct answer (1170) = **3** marks*

1

(ii) energy released forming new bonds is greater than energy needed to break existing bonds owtte

allow converse

*do **not** accept energy needed to form new bonds greater than energy needed to break existing bonds*

1

[6]

Q2.

(a) (i) high temperature

accept temperature given if ≥ 400 °C
ignore value if "high" stated, unless silly value

1

endothermic or reaction takes in energy

or Δ H is +ve

independent marks

1

(ii) low pressure

or up to and including 10 atmospheres

1

(low pressure) favours a reaction in which more molecules are formed

2 moles → 4 moles
(2 molecules → 4 molecules)

independent marks

1

(iii) nickel **and** it is a transition / transitional element / metal (owtte) **or** nickel **and** variable oxidation state / number or it is similar to other named transition elements e.g. iron

1

(b) (i) (bonds broken =) 2005 (kJ)

1

(bonds formed =) 2046 (kJ)

1

energy change = 2005 – 2046 = (–)41

for correct subtraction ignore sign

1

(ii) (exothermic)

if in part (b)(i) answer is not 41
answer is consequential on endothermic or exothermic shown

*accept correct reasoning for **incorrect** answer from (b)(i)*

energy given out forming new bonds

*do **not** accept energy needed to form new bonds*

1

greater than energy put in to break old bonds

*accept exothermic **and** more energy given out than taken in for 1 mark*
*accept negative value for energy change **or** energy in products less than energy in reactants for 1 mark*

1

[10]

Q3.

(a) (i) high **and** low

both needed for mark

1

(ii) reversible

1

(iii) to prevent ammonium chloride / solid / particles escaping

idea of a filter

*do **not** accept 'to prevent gases escaping'*

1

(b) endothermic

1

[4]

Q4.

(a) M_r (SiO_2) = 60

if M_r incorrect ecf for max 2

1

60 g SiO_2 → 28 g Si

*correct answer for **3** marks*

1

2.14 g SiO_2 → 1 g Si

allow 2, 2.1, 2.14 (or anything rounding to 2.14), 2.16 or 2.2

a unit is not required but an incorrect unit loses the third mark

OR M_r (SiO_2) = 60 (1)

moles if silicon needed = $\frac{1}{28}$ = 0.0357

mass of SiO_2 needed = 0.0357 × 60 (1)

= 2.14 g (1)

allow 2, 2.1, 2.14 (or anything rounding to 2.14), 2.16 or 2.2

OR M_r (SiO_2) = 60 (1)

mass SiO_2 = 1 × $\left(\frac{60}{28}\right)$ (1)

= 2.14 g (1)

allow 2, 2.1, 2.4 (or anything rounding to 2.14), 2.16 or 2.2

3

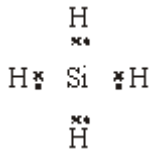
(b) (i) $MgO(s) + 2HCl(aq) \rightarrow MgCl_2(aq) + H_2O(l)$

*penalise incorrect symbols correctly balanced equation for **1** mark state symbols for **1** mark*

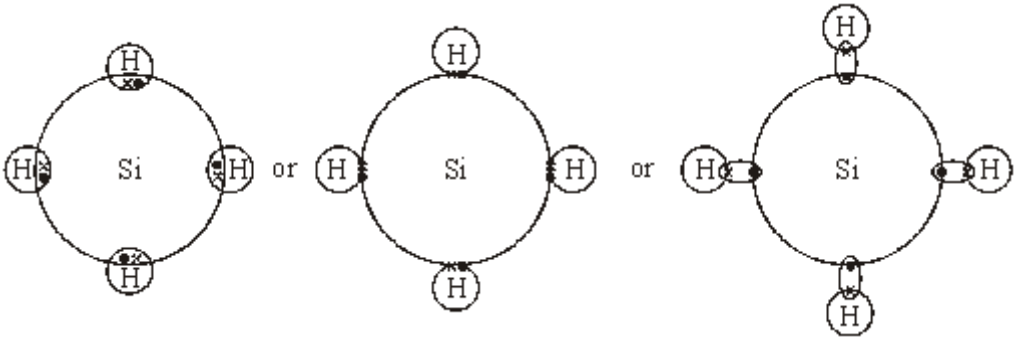
allow correct multiples / fractions

2

(ii)



or



ignore inner shell electrons of silicon
allow correct drawings without symbols
must clearly indicate four shared pairs of electrons with one electron from each atom

(iii)

Si	**H**
$\frac{1.4}{28}$	$\frac{0.15}{1}$

1

= 0.05 = 0.15

1

1 3

for whole number ratio can be implied

1

SiH_3

*accept H_3Si **or** any correct formula with 1:3 ratio*
if in step 1 they get either of ratios incorrect they lose first 2 marks but can be ecf for 3rd and 4th mark
evidence of mass / A_r ***1*** *mark*
proportions of each ***1*** *mark*
whole number ratio ***1*** *mark*
correct formula ***1*** *mark*

1

(iv) **C**

accept c

1

(c) any **four** from:

- giant structure / macromolecule / lattice / giant molecule
  allow giant molecular / giant atomic structure

- each silicon atom joined to four other atoms
  (or diagram)
- covalent bonds
- bonds are strong **or** large amount of energy needed to break bonds
  accept hard to break bonds
- large number of bonds to be broken
  *mention of giant **ionic** structure **or** intermolecular forces **or** intermolecular bonds max **1** mark*
  *diamond **or** carbon discussion max **3** marks unless clearly linked to silicon*

4

[15]

Q5.

(a) sodium
hydrogen
phosphorus
oxygen

***2** marks for all 4*
***1** mark for 2 or 3*
***0** marks for 0 or 1*
not symbols / formulae

2

(b) (i) gives out
gets hot(ter) / temperature rises (1)

1

heat / energy
independent mark

1

(ii) **Quality of written communication**
for clearly expressed ideas

1

take temperature of water at start
owtte

1

take temperature after adding soup powder

1

plus any **one** from:

- using a thermometer
- mix / stir / shake etc
- in beaker / conical flask / test tube / plastic cup

- temperature will rise (indicates an exothermic reaction)

1

[8]

Q6.

(a) (i) yield increases

two marks are linked

1

because more (gaseous) reactant molecules / particles than (gaseous) product molecules / particles

accept 7 → 4 moles or volumes
ignore more reactants
accept fewer particles on the right

1

(ii) increased (rate) / faster / speeds up etc

two marks are linked

1

more collisions **or** increased concentration **or** particles closer together

greater chance of more successful collisions

1

(b) heat / high temperatures

*do **not** accept burn it ignore cracking / catalyst*

1

[5]

Q7.

(i) 436 + 242 = 678 (kJ) [1]

2 × 431 = 862(kJ) [1]

answer = 184

*first **two** marks can be awarded if answer is incorrect*
ignore sign

3

(ii) exothermic

1

more energy released by, bond formation than needed for bond breaking

both parts to be marked depending on answers given in (b)(i)

1

(iii) hydrogen chloride is (a) covalent (compound)

1

when added to water it forms ions **or** H^+ (and Cl^-)

1

hydrogen ions **or** H^+ causes a solution to be acidic

1

[8]

Q8.

(a) exothermic (reaction)

1

(b) smaller lumps react faster
or larger lumps react slower

accept smaller lumps cause a more rapid rise in temperature ***or*** *vice versa*

do ***not*** *accept higher temperature* ***or*** *more heat unless linked to time*

1

smaller lumps have a larger surface (area) or larger lumps have a smaller surface (area)

more water can react at the same time ***or*** *so less water can react at the same time*

1

(c) heats up (too) rapidly

accept temperature (too) high

1

burning the food **or** the hands

accept danger of container exploding ***or*** *splitting* ***or*** *food overheating*

do not accept reference to handling of powder

do ***not*** *accept a lot of powder needed* ***or*** *powder getting into food* ***or*** *too hot to eat* ***or*** *food would not cook properly* ***or*** *heat through properly*

1

[5]

Q9.

rises as energy needed for bond breaking (of reactants)

1

called activation energy **or** correctly labelled on diagram

1

bond making (to form products) releases energy

1

called exothermic reaction **or** more energy given out than taken in **or** releases heat to the surroundings

1

[4]

Q10.

(i) the energy needed by reactants before reaction can occur

accept energy required for particles to collide successfully

accept energy required to break bonds
accept energy needed to start reaction

1

(ii) reference to reactants 'energy' higher than products 'energy'
accept exothermic reaction
accept heat (energy) released

1

melting point of iron is exceeded
accept temperature is above melting point of iron

1

[3]

Q11.

(a) (i) fertilisers
for 1 mark

1

(ii) 7
for 1 mark

1

(iii) 5
for 1 mark
(ignore other units)

1

(b) (i) both nitrogen and hydrogen
for 1 mark

1

(ii) two of:
nitrogen;
hydrogen/methane/natural gas;
oxygen/air;
water;
any fuel
(allow symbols, do not allow nitrogen oxides)
any two for 1 mark each

2

(c) (i) alkali/alkaline/base/basic
for 1 mark

1

(ii) must be nitrate
for 1 mark

1

(iii) thermometer or any other temperature measuring device
for 1 mark

1

[9]

Q12.

(a) gives out

heat

each for 1 mark

2

(b) chromium and aluminium oxide

1

(c) (i) chromium oxide

1

(ii) oxygen removed/gains electrons

1

[5]

Q13.

(a) oxygen/O_2

for 1 mark

1

(b) water/H_2O

for 1 mark

1

(c) carbon dioxide/CO_2
(if symbols are used they must be correct)

for 1 mark

1

(d) gives out

for 1 mark

1

heat or energy (2 independent marks)

for 1 mark

1

[5]

Q14.

(a) (i) 4 E (H-O) = 4 × 464 = 1856
2 E (O-O) = 2 × l46 = 292

gains 1 mark each

but Total = 2148 kJ
Deduct one mark for each mistake.
Answer of 1074 kJ gains 1 mark. (Candidate has ignored the 2 in front of the brackets.)

gains 2 marks

2

(ii) 4 E (H-O) = 4 × 464 = 1856
E (O=O) = 498
gains 1 mark each

but Total = 2354 kJ
Deduct one mark for each mistake.
Answer of 1426 kJ gains 1 mark. (Candidate has ignored the 2 in front of the brackets.)
gains 2 marks

2

(iii) 2354 – 2148 = 206 kJ (Ignore any signs)
Answer is consequential on their answers to (i) and (ii).
for 1 mark

1

(iv) exothermic because (more) heat is given out (than put it) / or
ΔH is negative /answer to (iii) is negative.).
(If the candidate gives the answer 'endothermic because heat /energy is taken in' then look back to their answers to (i) and (ii). If (i) is greater than (ii) then accept this answer.
for 1 mark

1

(b) (i) eg minimum energy for reaction
energy needed to start a reaction
energy needed to break bonds
energy needed to make two substances react
(Energy linked to starting a reaction.)
for 1 mark

1

(ii) B
for 1 mark

1

(iii) lowers activation energy / needs less energy to start reaction / less energetic route
for 1 mark

1

[9]

Q15.

(i) sulphuric acid / H_2SO_4
accept sulfuric *1 for one mark*

1

(ii) exothermic
for one mark

1

(iii) Na_2SO_4 / $(Na)_2SO_4$ / $Na_2(SO_4)$ / $(Na^+)_2SO_4^{2-}$

for one mark
lower case O(Na_2SO_4) not accepted / tops of subscripted letters should be in line or lower than lower case letters of symbols

1

[3]

Q16.

(a) (i) sulphuric acid / H_2SO_4 (accept sulfuric)

for one mark

1

(ii) Na_2SO_4 / $(Na)_2SO_4$ / $Na_2(SO_4)$ / $(Na_+)_2SO_4^{2-}$

for one mark

lower case O (Na_2So_4) not accepted/tops of subscripted numbers should be in line with or lower than lower case letters of symbols / upper case 'a' not accepted

1

(b) (i) exothermic

for one mark

1

(ii) 60 KJ

for one mark

1

(iii) energy given out when bonds form
energy taken in when bonds break
energy given out is greater then energy taken in (owtte)

for 1 mark each

3

(iv) activation energy is low / many molecules have enough energy to react
for one mark

1

[8]

Q17.

(a) (1) + 3 → 2 + 3

accept correct multiples

1

(b) any **three** from

- to react particles must collide
- with sufficient energy
- reference to activation energy
- (to cause) bond breaking

3

(c) (i) (436 × 2) + 498

1

= 1370 (kJ)

accept (436 × 2) + 498 ***or*** *934 kJ for one mark*
allow 2 marks for 1370 if no working
or *correct working is shown*

1

(ii) calculation of bond energy or product

1

464 + 464 = 928 × 2 = 1856

incorrect calculation = 0 marks

correct deduction

allow deduction on ecf exothermic / endothermic on own without calculation are neutral

1

[8]

Q18.

exothermic does **not** gain any credit

1

reactants: bond breaking (436 + 242 =) 678 (kJ)

1

products: bond making (2 × 431 =) 862(kJ)

so overall 184 (kJ) released / –184(kJ)

1

[3]

Q19.

(a) increases % / amount of ammonia

1

favours the forward reaction

1

(b) reaction(s) would be too slow

1

(c) any **three** from:

- rate increased
- decreases % / amount of ammonia
- the forward reaction is exothermic
- the backward reaction is endothermic
- backward reaction favoured / forward reaction not favoured
- yield / amount of nitrogen and hydrogen increased

- the relative amount (yield) of ammonia decreases as the equilibrium is changed
- the relative amount (yield) of nitrogen and hydrogen increases as the equilibrium is changed

explanations in terms of particles are neutral

3

[6]

Q20.

(a) Bunsen (burner)

accept spirit burner do not credit candle

1

(b) blue

1

white

credit (1) if both colours correct but answers are reversed

1

to cool the tube (B)

*accept answers which anticipate part (d) e.g. 'to condense the water vapour' or gases **or** vapours*

1

(d) (i) water

do not credit 'condensation'

1

(ii) (Water) vapour from the crystals (from tube A)

*accept steam **or** steam from tube A*

1

condenses **or** cools

accept turns to (liquid) water

1

(e) add water

gets hot **or** hotter **or** warm **or** warmer turns into solution
dissolves

or the temperature rises or there is an exothermic reaction
*accept steams **or** hisses ignore any reference to colour(s)*

2

(f) sulphuric acid

accept H_2S0_4 only if correct in every detail

1

[10]

Q21.

(a)

	bonds broken	bonds made
C – C	2 (4)	
C – H	12 (10)	
O = O	7	
C = O		8
H – O		12

1 mark for all bond breaking correct

1 mark for all bond making correct

2

(b) 1 mark for the three energy levels drawn

1

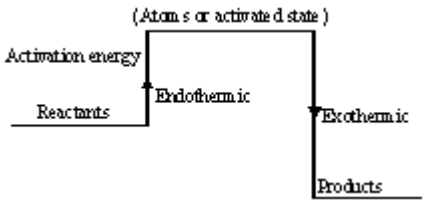
1 mark is for products and reactants labelled, with products shown lower than reactants

1

1 mark for activation energy in the correct position

1

(c) 1 mark (for arrows) and endothermic
exothermic labels



arrows not required

1

lowers activation energy

1

more particles have the energy to react

particles do not need as much energy to react

1

[8]

Q22.

NOTE

In this question and throughout the Paper, if the name of a chemical is asked for, then the formula is acceptable only if it is correct in every detail. If the name is correct and the candidate has tried to be 'helpful' by giving, in addition, an incorrect version of the formula, then this is acceptable provided it does not lead to ambiguity.

(i) nitric (acid)

accept $HN0_3$

1

(ii) sulphuric (acid)

accept H_2SO_4

1

(iii) heat given out

***or** temperature rise*

***or** energy given out*

***or** steam*

do not credit just 'use a thermometer'

do not credit just 'change in temperature'

1

(iv) neutralisation

accept neutralise

accept neutral

*accept formation of salt **or** water*

do not credit exothermic

1

[4]

Q23.

(a) heat/light

1

(b) any reference to the products being (colourless) gases/smoke

1

[2]

Q24.

(a) breaking of C-H bonds
breaking of O-O bonds
making of C-O bonds

for 1 mark each

making of H-O bonds

4

(b) X energy needed to break bonds
has to be **supplied**/activation energy

Y energy released when bonds form

Z = Y-X
overall, energy is released/reaction is exothermic

each for 1 mark

5

[9]

Q25.

(i) Bonds broken
4 × (C – H)
2 × (O = O)
each for 1 mark

Bonds formed
2 × (C = O)
4 × (O – H)
each for 1 mark

4

(ii) Total energy change in breaking bonds
(4 × 413) + (2 × 498)
each gains 1 mark

Total energy change in forming bonds
(2 × 805) + (4 × 464)
but
to break bonds = 2648
to form bonds = 3466
each gains 2 marks

4

(iii) nett energy transfer = 818 (kj)
this energy is released in the reaction/is an exothermic reaction
(*credit answers consistent with (ii) or derived from the initial information)*
each for 1 mark

2

[10]

Q26.

(a)

Bonds broken		Bonds formed	
number	type	number	type
3	[O=O]	4	[O–H]

each for 1 mark

2

(b)

Total energy change in breaking bonds	Total energy change in forming bonds
3 × 498 = 1494	4 × 464 = 1856

each for 1 mark

Total = 3758 Total = 5076
each for 1 mark

4

(c) net energy transfer = 1318
this energy is released in the reaction/it is an exothermic reaction
each for 1 mark

[N.B. credit e.c.f. (a) → (b) and (b) → (c)]

2

[8]

Q27.

(a) fuels
heat – allow light
for 1 mark each

2

(b) gases
for 1 mark

1

[3]

Q28.

(a) (i) oxygen (not air)

(ii) oxides/monoxides/dioxides
for 1 mark each

Do not allow specific examples

2

(b) (i) water

(ii) sulphur

(iii) carbon
for 1 mark each

3

(c) gives out/releases heat/energy
for 1 mark

1

(d) (i) carbon dioxide

(ii) carbon
for 1 mark each

(allow correct symbols/formulae)

2

[8]

Q29.

(a) nitrogen / N2
[Do not allow N or N^2] for 1 mark

(b) heat
for 1 mark

(c) carbon dioxide / CO_2

for 1 mark

[3]

Q30.

ideas that

- x = the energy required / taken in / used* to break the bonds of water / reactant [*not used up / formed]

  gains 1 mark

- **but =** the energy required taken in / used to break the bonds in water **or** activation energy

  gains 2 marks

- y = the energy released given out when bonds form

  gains 1 mark

- **but =** the energy released / given out when hydrogen / oxygen form

  gains 2 marks

- z = 1856 – 1370 or (+)486 kJ

  for 1 mark

or difference between x and y **or** net energy transferred

- overall, energy is taken in / absorbed in the reaction
  or the reaction is endothermic **or** energy required to break existing bonds is > energy released when new bonds form

  for 1 mark

[6]

Q31.

(a) heat
light
an exothermic

in any order for 1 mark each

3

(b) oxygen / O_2

for 1 mark

1

[4]

Q32.

(a) *idea that*
existing bonds must first be broken

for 1 mark

(*credit* molecules / atoms more likely to react when they collide)

energy is released when new bonds form

gains 1 mark

but more energy is released when new bonds form

gains 2 marks

or overall reaction exothermic
this breaks more bonds so the reaction continues

for 1 mark

max 4

(b)
- reactant level higher than product level (names of reactants and products not required)
- indication that activation energy required (i.e. the “hump”)
- any correct indication of nett energy change

(i.e. between product and reactant levels even if other marks not gained)

for 1 mark each

3

[7]