Calculating and Explaining Energy Changes

Question Paper

Level	GCSE
Subject	Chemistry
Exam Board	AQA
Unit	C3
Topic	Calculating and Explaining Energy Changes
Difficulty Level	Silver Level
Booklet	Question Paper

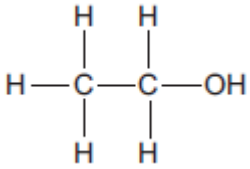
Time Allowed: **82 minutes**

Score: **/82**

Percentage: **/100**

Q1.(a) The structure of an alcohol is shown in **Figure 1**.

Figure 1



(i) Draw a circle around the functional group in the structure of the alcohol.

(1)

(ii) What is the chemical name of this alcohol?

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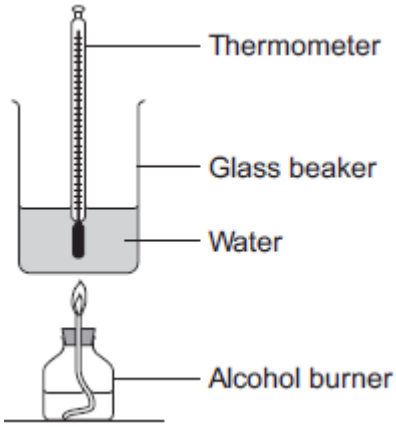
(1)

(b) Alcohols are used as fuels.

A student plans an experiment to find the energy released per gram of alcohol burned.

The student uses the apparatus shown in **Figure 2**.

Figure 2



(i) Suggest **two** ways that this apparatus could be improved to obtain accurate results.

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(2)

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

Describe how the student should do this experiment.

You should include any measurements the student should make.

Do **not** describe any improvements to the apparatus.

Do **not** describe how to do any calculations.

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Extra space .....

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(6)
(Total 10 marks)

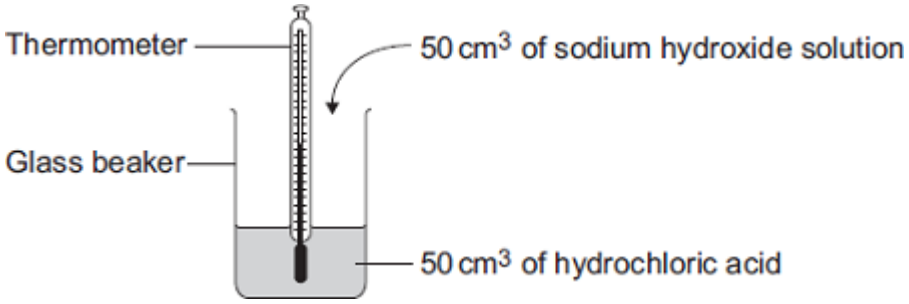
Q2. Read the information about energy changes and then answer the questions.

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.

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(1)

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

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(1)

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

.....

Answer = ... °C

(1)

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

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

.....

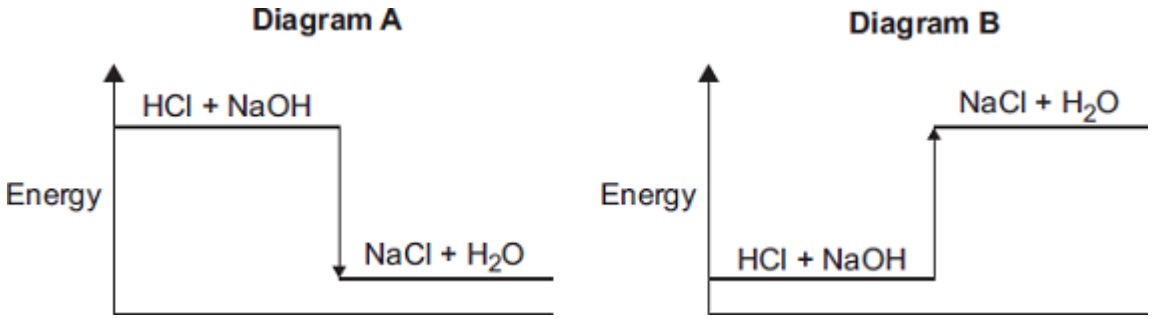
Answer = ... J

(1)

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

this reaction?

Give a reason for your answer.



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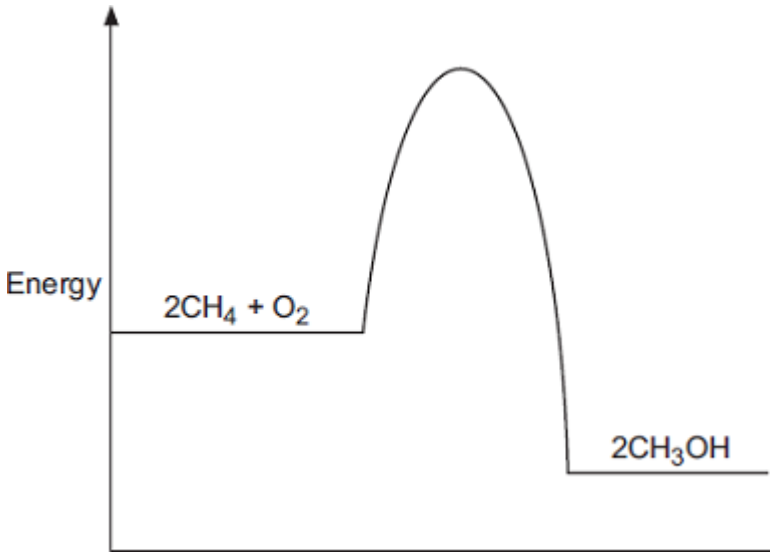
(1)
(Total 7 marks)

Q3. 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?

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(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?

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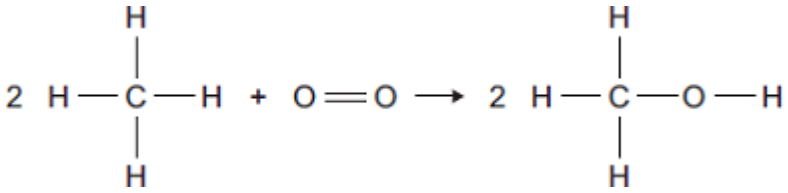
(1)

(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

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Energy change = ... kJ

(3)

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

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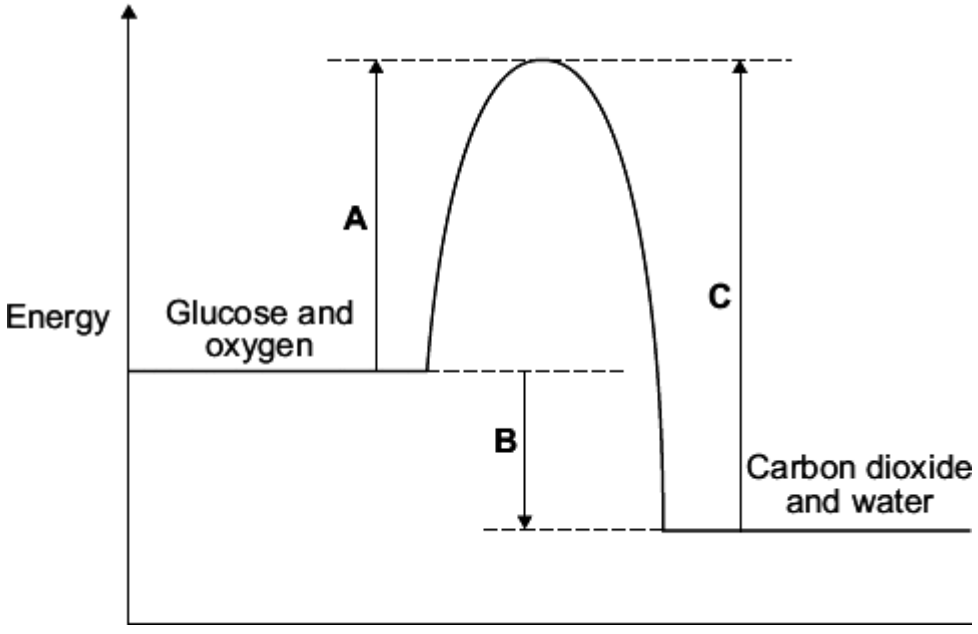
(1)

(Total 6 marks)

Q4. Food provides chemicals and energy to keep your body working. In your body, energy is released by respiration when glucose, $C_6H_{12}O_6$, reacts with oxygen.

$C_6H_{12}O_6 + 6\ O_2 \rightarrow 6\ CO_2 + 6\ H_2O$

(a) The energy level diagram for the reaction of glucose with oxygen is shown.



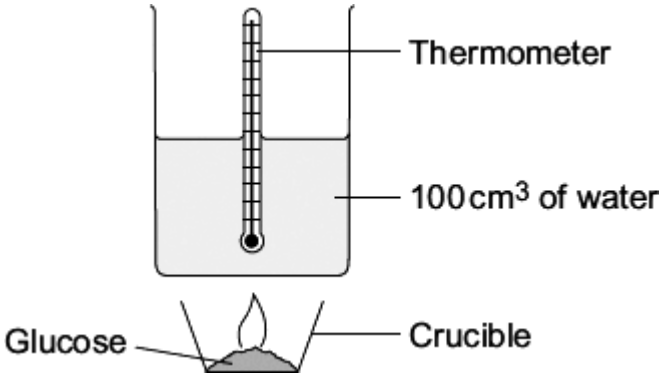
(i) Which energy change, **A**, **B** or **C**, represents the activation energy?

(1)

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

(1)

(b) A student did an investigation to find the amount of energy released when 1 g of glucose burns in air.



The student:

- recorded the room temperature
- placed 1 g of glucose into the crucible
- set up the equipment as shown in the diagram
- lit the glucose
- recorded the highest temperature of the water.

(i) One of the main errors in this experiment is energy loss to the surroundings.

Suggest **one** way that the equipment could be changed to reduce this energy loss.

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(1)

(ii) The room temperature was 20 °C and the highest temperature recorded was 42 °C.
Use these temperature readings to calculate how much energy is released when 1 g of glucose burns.
The equation that you need to use is:

Energy released in joules = 100 × 4.2 × temperature change

Show clearly how you work out your answer.

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Burning 1 g of glucose releases ..... joules

(2)

(iii) The amount of energy released by 1 g of glucose should be 16 000 J.

Apart from energy loss to the surroundings, suggest **two** other reasons why the student's value was less than expected.

1 .....

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2 .....

.....

(2)

(c) Suggest **one** reason why food labels provide information about the energy released by the food.

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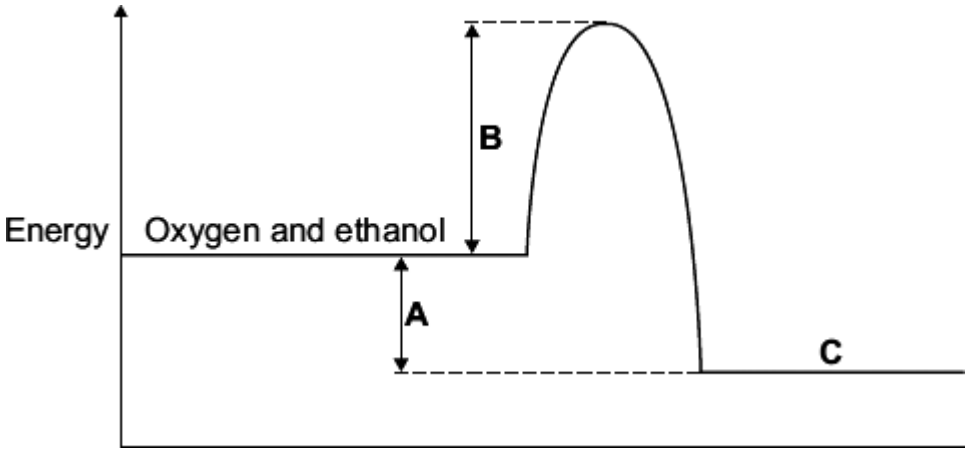
(1)
(Total 8 marks)

Q5. 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?

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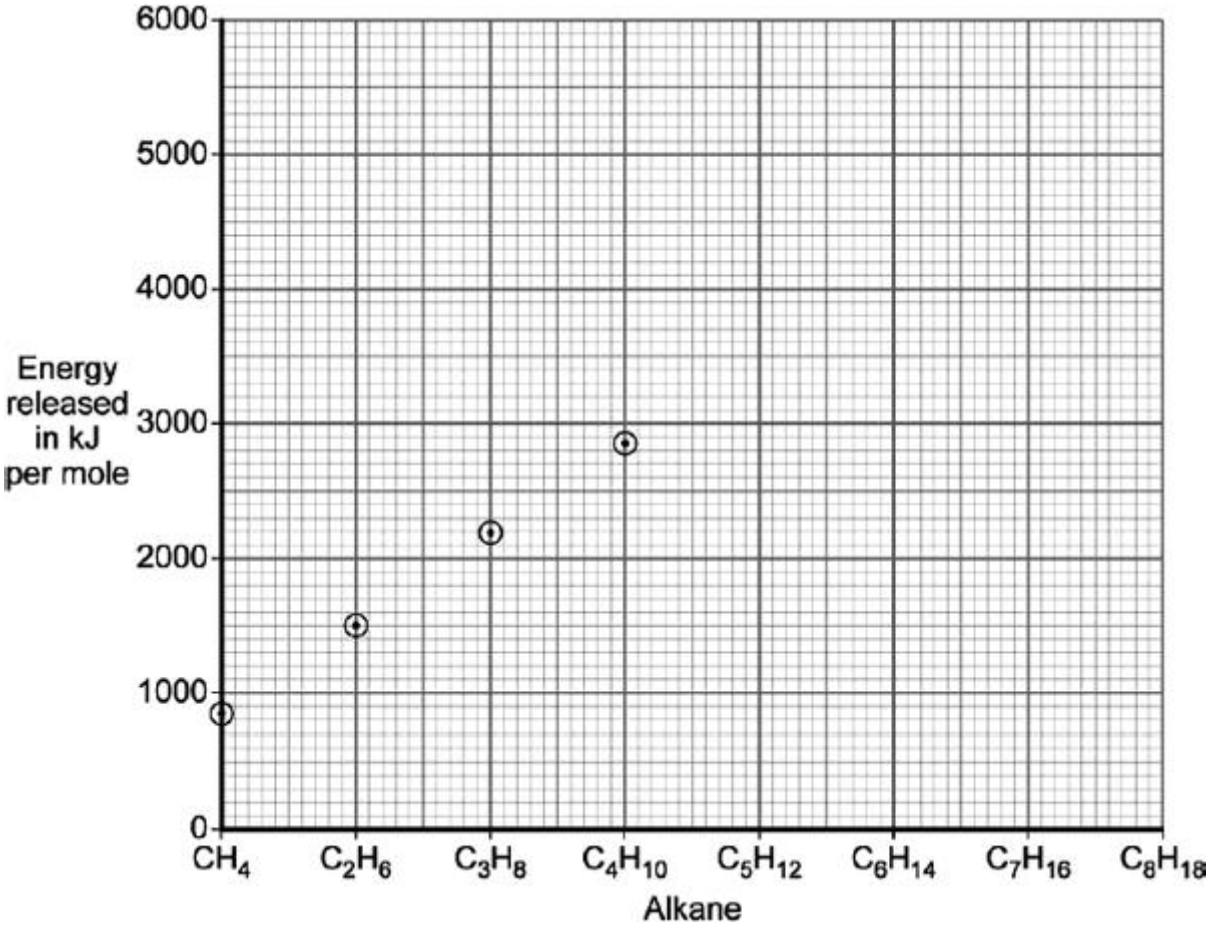
(1)
(Total 4 marks)

Q6. (a) Alkanes are important hydrocarbon fuels. They have the general formula C_nH_{2n+2}

The points on the graph show the amount of energy released when 1 mole of methane (CH_4), ethane (C_2H_6), propane (C_3H_8) and butane (C_4H_{10}) are burned separately.



(i) Draw a line through the points and extend your line to the right-hand edge of the graph.

(1)

(ii) Use the graph to estimate the amount of energy released when 1 mole of octane (C_8H_{18}) is burned.

Energy released = ... kJ

(1)

(iii) Suggest why we can make a good estimate for the energy released by 1 mole of pentane (C_5H_{12}).

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(1)

(iv) A student noticed that octane (C_8H_{18}) has twice as many carbon atoms as butane (C_4H_{10}), and made the following prediction:

"When burned, 1 mole of octane releases twice as much energy as 1 mole of butane."

Use the graph to decide if the student's prediction is correct. You **must** show your working to gain credit.

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(2)

(b) Some information about four fuels is given in the table.

			Combustion products			
Fuel	**Type**	**Heat released in kJ per g**	**CO_2**	**SO_2**	**H_2O**	**Type of flame**
Bio-ethanol	Renewable	29	✓		✓	Not smoky
Coal	Non-renewable	31	✓	✓	✓	Smoky
Hydrogen	Renewable	142			✓	Not smoky
Natural gas	Non-renewable	56	✓		✓	Not smoky

From this information a student made two conclusions.

For each conclusion, state if it is correct **and** explain your answer.

(i) "Renewable fuels release more heat per gram than non-renewable fuels."

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(2)

(ii) "Non-renewable fuels are better for the environment than renewable fuels."

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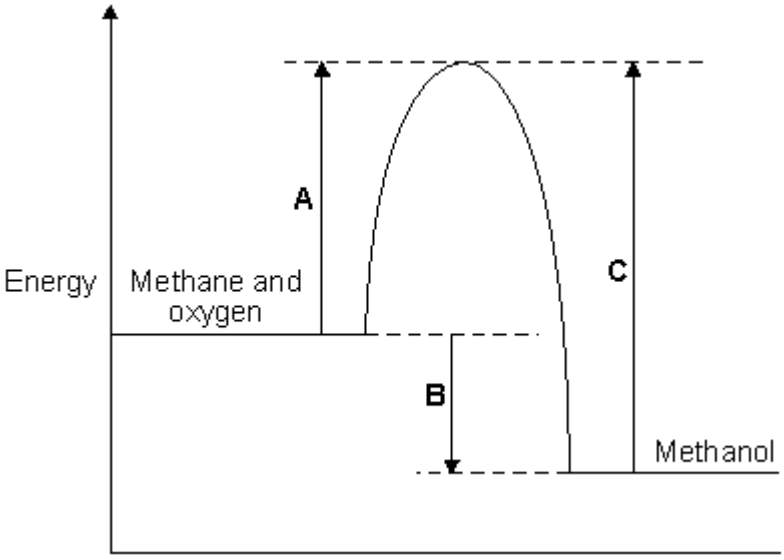
(2)
(Total 9 marks)

Q7. Methanol can be made when methane reacts with oxygen.

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



(i) What is the energy change represented by **A**?

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(1)

(ii) Use the energy level diagram to explain how it shows that this reaction is exothermic.

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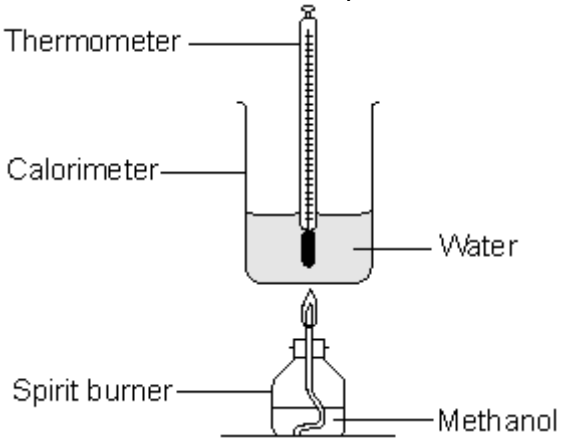
(2)

(b) A student did an experiment to find the energy released when methanol burns in air.

The student:

- weighed a spirit burner containing methanol
- set up the equipment as shown in the diagram
- recorded the initial temperature



- lit the spirit burner
- put out the flame when the temperature of the water had risen by about 20 °C
- stirred the water and recorded the highest temperature of the water
- reweighed the spirit burner containing the methanol.

The student repeated the experiment and recorded his results.

	Experiment 1	Experiment 2	Experiment 3

Initial mass of spirit burner and methanol in g	299.3	298.3	296.9
Final mass of spirit burner and methanol in g	298.3	297.1	295.9
Initial temperature in °C	23	22	23
Highest temperature in °C	45	50	43
Temperature change in °C	22	28	20

Use the diagram and the information in the table to answer the questions.

(i) The main error in this experiment is energy loss.

Suggest **one** way that the equipment could be changed to reduce energy loss.

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(1)

(ii) The temperature change in Experiment 2 is greater than the temperature change in Experiment 1 **and** Experiment 3.

Explain why.

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(2)

(iii) Suggest **one** reason why the student repeated the experiment.

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(1)

(iv) Use the temperature change in Experiments 1 **and** 3 to calculate how much energy is released when 1g of methanol burns. The equation that you need to use is:

Energy released in joules = 100 x 4.2 x mean temperature change

Show clearly how you work out your answer.

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Burning 1g of methanol releases ..... J

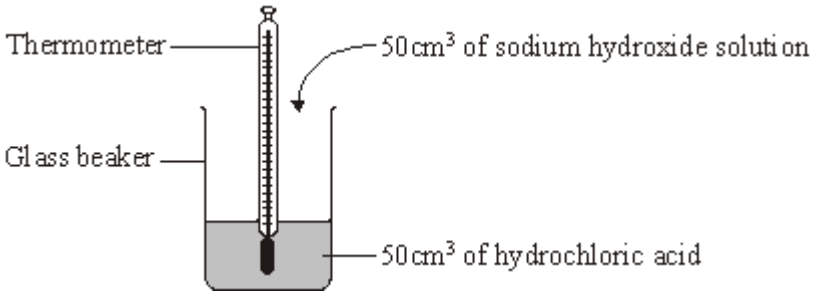
(2)
(Total 9 marks)

Q8. 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 cm3 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.

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.....

(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.

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.....

(1)

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

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.....

(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.

Diagram A

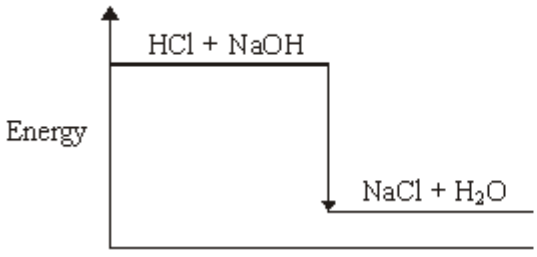
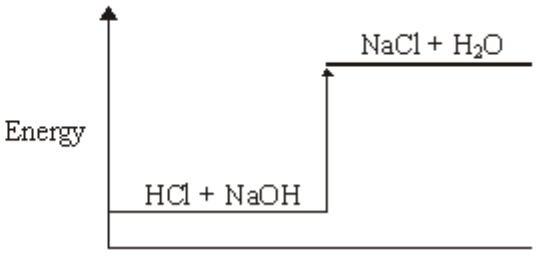


Diagram B



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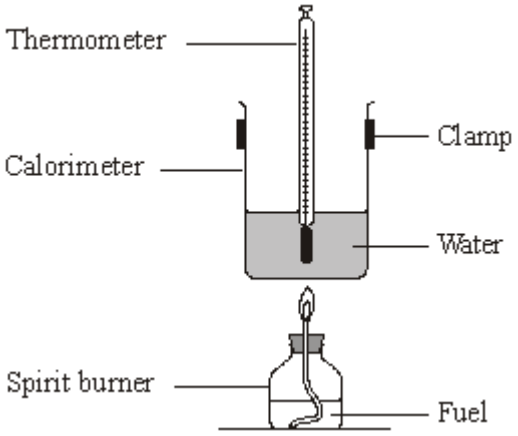
(1)

(Total 7 marks)

Q9. 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.

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(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.

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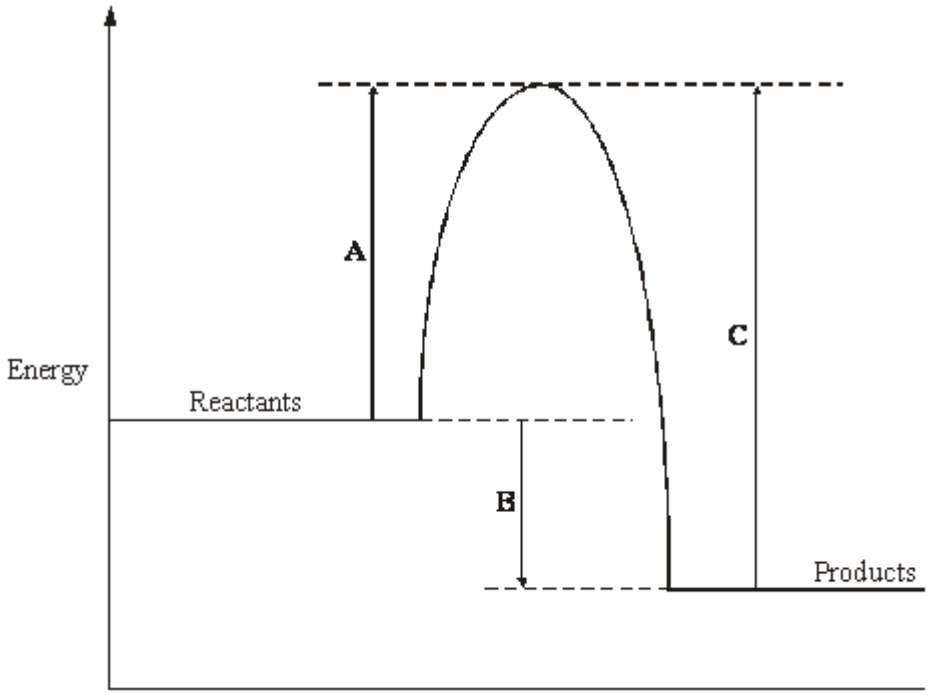
(2)

(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)

Q10. HYDROGEN FUEL OF THE FUTURE

It has been suggested that hydrogen could be used as a fuel instead of the fossil fuels that are used at present. The equation below shows how hydrogen burns in air.

$$2H_2 + O_2 \rightarrow 2H_2O + \text{heat}$$

The hydrogen would be made from water using energy obtained from renewable sources such as wind or solar power. The water splitting reaction requires a lot of energy.

(a) Hydrogen was successfully used as a fuel for a Soviet airliner in 1988.
Why would hydrogen be a good fuel for use in an aeroplane?

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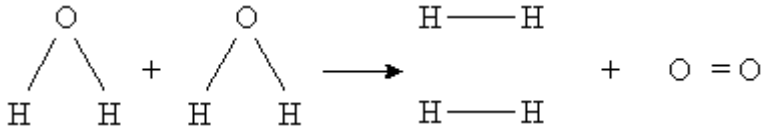
(2)

(b) The water splitting reaction is shown in the equation below.

$$2H_2O \rightarrow 2H_2 + O_2$$



Calculate the energy needed to split the water molecules in the equation into H and O atoms.

$$2H_2O \rightarrow 4H + 2O$$

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(2)

(c) On the Periodic Table, hydrogen is placed on its own at the top and in the middle. It is difficult to position it because it has the properties of metals and non-metals.

(i) Where would you expect hydrogen to be placed on the periodic table on the basis of the arrangement of electrons in hydrogen atoms?

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(1)

Explain your answer.

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(1)

(ii) Give **one** way in which hydrogen behaves like a metal.

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(1)

(iii) Give **one** way in which hydrogen behaves like a non-metal.

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(1)

(Total 8 marks)

Q11. (a) (i) Which acid should the student add to sodium hydroxide solution to make sodium sulphate?

..... acid

(1)

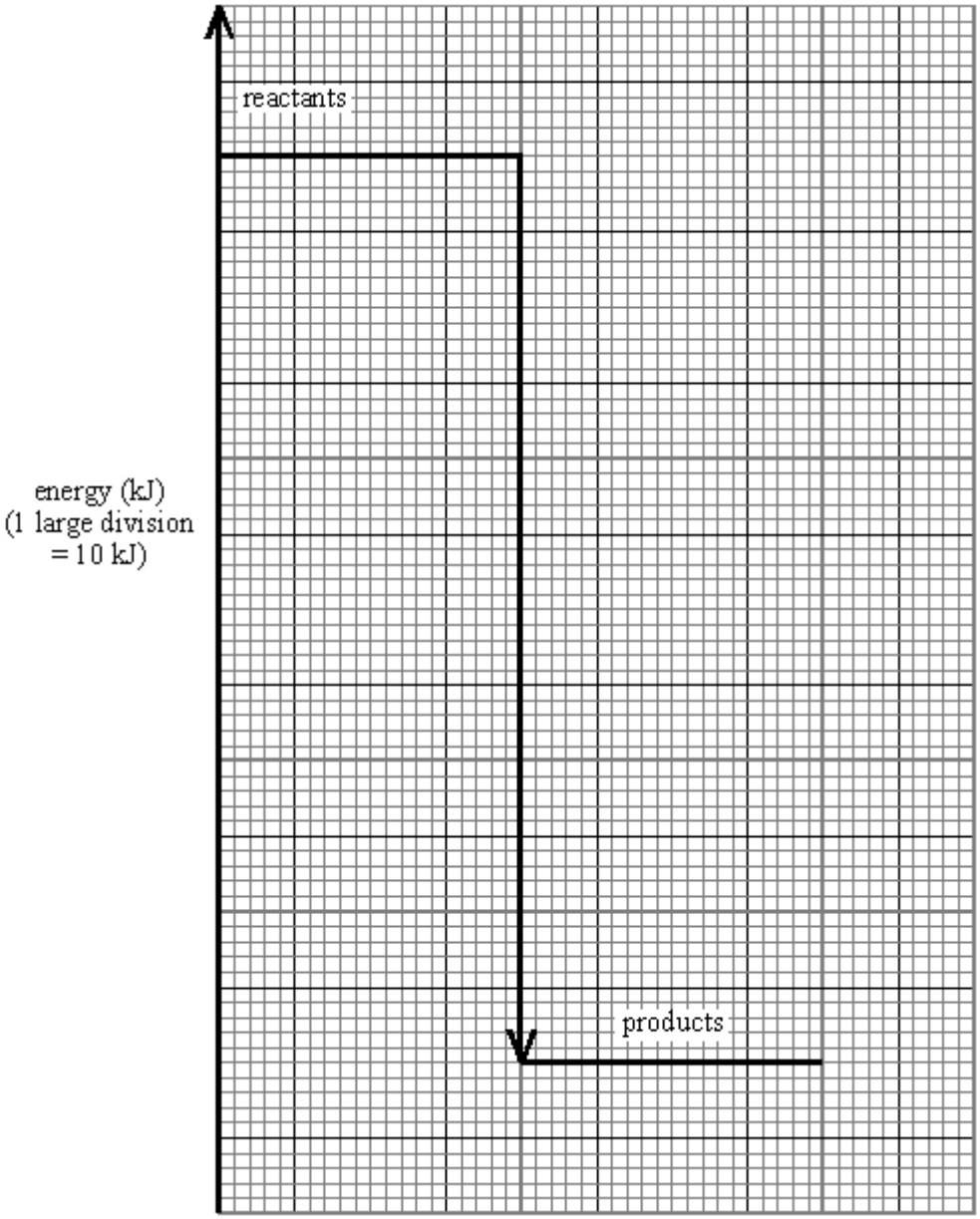
(ii) Use the table on the Data Sheet to help you to write the formula of sodium

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?

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(1)

(ii) Use the energy diagram to calculate a value for the amount of energy released during this reaction.

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Energy released ..... kJ

(1)

(iii) Explain, in terms of bond breaking and bond forming, why energy is released during this reaction.

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(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?

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(1)

(Total 8 marks)