Energetics

Question Paper

Level	GCSE
Subject	Chemistry
Exam Board	Edexcel IGCSE
Module	Single Award (Paper 2C)
Topic	Physical Chemistry
Sub-Topic	Energetics
Booklet	Question Paper

Time Allowed: **73 minutes**

Score: **/61**

Percentage: **/100**

Grade Boundaries:

A*	A	B	C	D	E	U
>85%	75%	70%	60%	55%	50%	<50%

1 A group of students planned an experiment to find the temperature rise in a neutralisation reaction. This is their method.

- Use a measuring cylinder to add 25 cm^3 of an alkali to a 100 cm^3 beaker
- Record the temperature of the alkali
- Use a burette to add an acid to the alkali in 5.0 cm^3 portions
- Record the temperature of the mixture after adding each portion of acid
- Stop the experiment when the neutralisation is complete

(a) The teacher asked the students about their method.

Suggest an answer to each of her questions.

(i) Why would it be better to use a pipette instead of a measuring cylinder?

(1)

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.....

(ii) It would be better if a polystyrene cup were used instead of a beaker.

What property of polystyrene makes this an improvement?

(1)

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.....

(iii) What extra step should there be between adding each portion of acid and measuring the temperature?

(1)

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(iv) How would you know when the neutralisation was complete?

(1)

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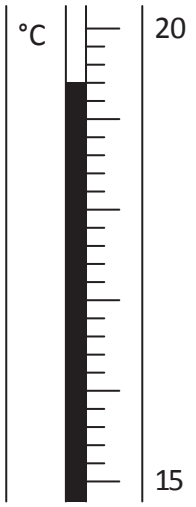
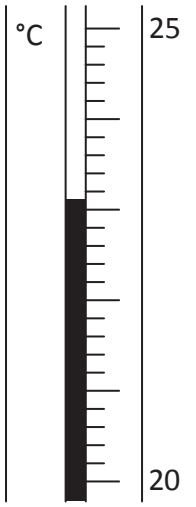
(b) The diagrams show the readings on the thermometer before and after one of the students added a portion of acid.



before adding acid



after adding acid

Write down the thermometer readings and calculate the temperature change.

(3)

Temperature before adding acid ..... °C

Temperature after adding acid ..... °C

Temperature change ..... °C

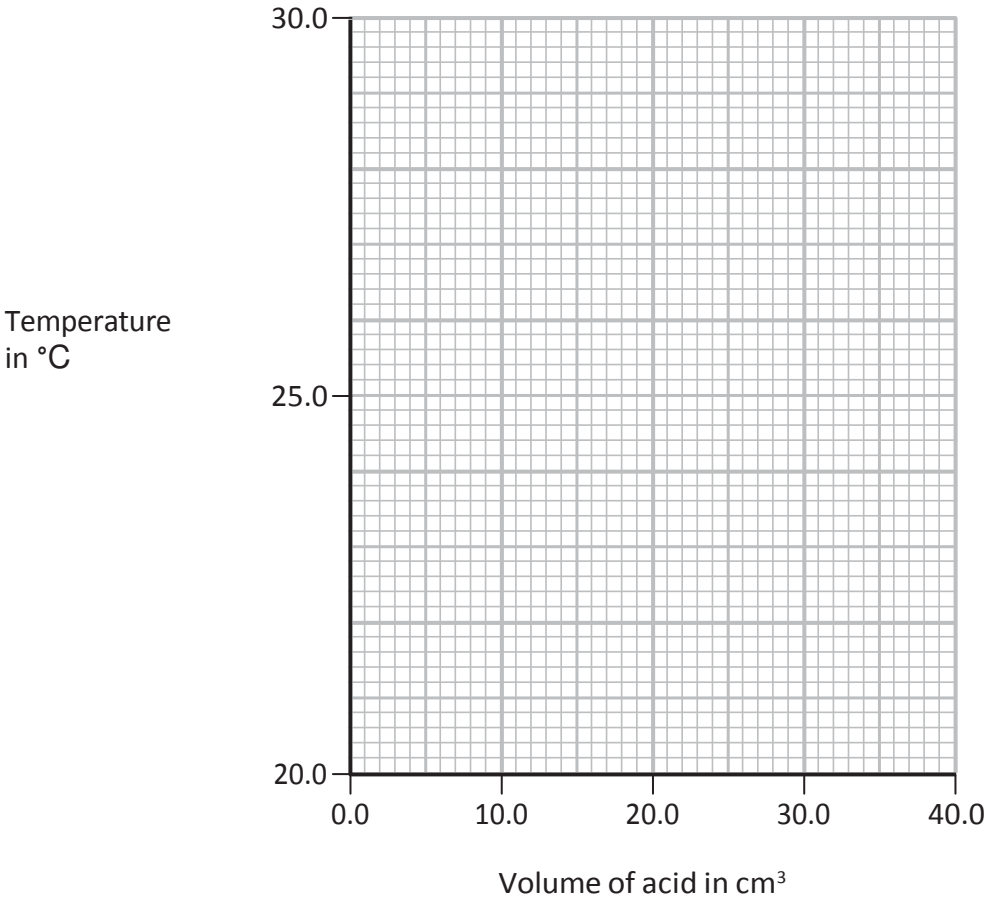
(c) One student obtained these results from an experiment in which she added a total of 40.0 cm^3 of hydrochloric acid to 25 cm^3 of sodium hydroxide solution.

Volume of acid in cm^3	0.0	5.0	10.0	15.0	20.0	25.0	30.0	35.0	40.0
Temperature in °C	21.0	22.3	24.4	26.2	27.8	27.8	27.5	26.7	26.2

(i) Plot a graph of these results on the grid below.

Draw a straight line of best fit through the first five points and another straight line of best fit through the last four points. Make sure that the two lines cross.

(4)



(ii) The point where the lines cross indicates the volume of acid needed to exactly neutralise the alkali, and also the maximum temperature reached.

Use your graph to record these values.

(2)

Volume of acid ..... cm^3

Maximum temperature ..... °C

(d) A second student used the same method and found that 30.0 cm^3 of acid were needed to neutralise 25 cm^3 of alkali.

He obtained a temperature rise of 5.5 °C in his experiment.

Calculate the heat energy change in this experiment using the expression:

heat energy change = total volume of mixture × 4.2 × temperature change

(2)

Heat energy change = ... J

(e) A third student calculated that the heat energy change in her experiment was 1800 J. This heat energy was released by the neutralisation of 25 cm^3 of 1.50 mol/dm^3 sodium hydroxide solution.

(i) Calculate the amount, in moles, of sodium hydroxide neutralised.

(2)

Amount = ... mol

(ii) Calculate the molar enthalpy change, in kJ/mol, for the neutralisation of sodium hydroxide.

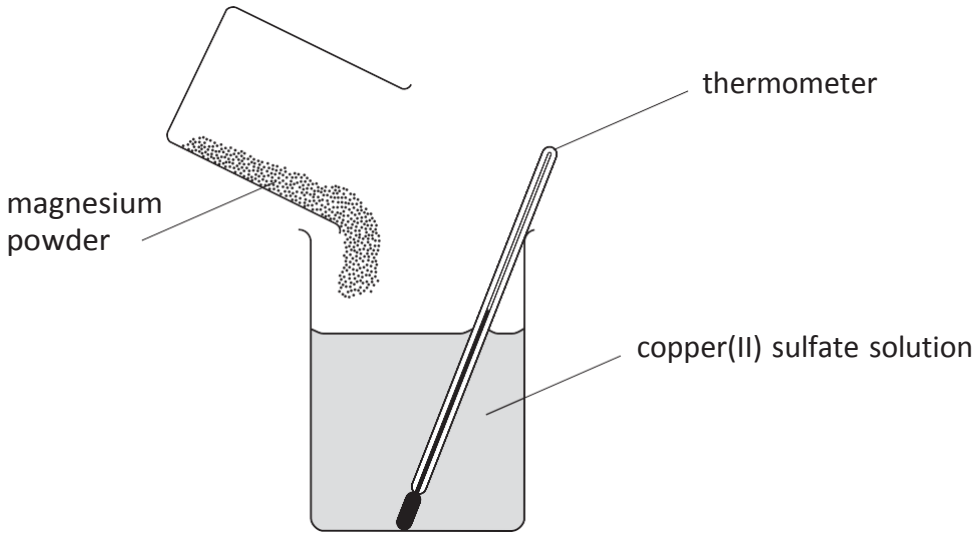
(2)

Molar enthalpy change = ... kJ/mol

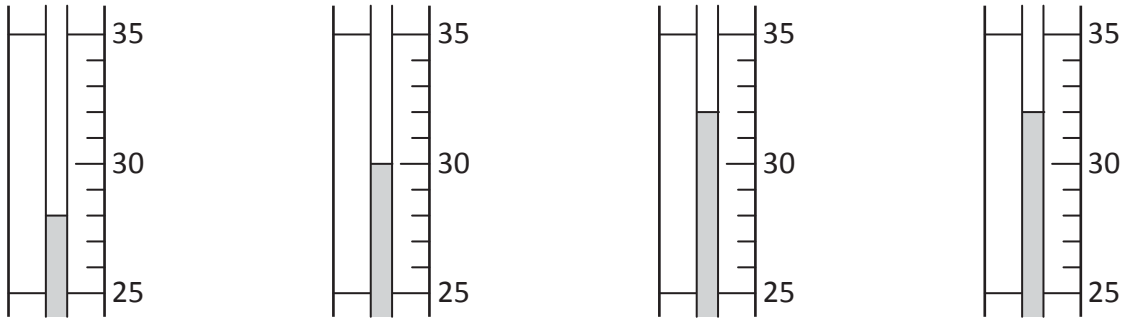
(Total for Question 1 = 19 marks)

2 A student measured the temperature change when 0.5 g of magnesium powder was added to 50 cm^3 of copper(II) sulfate solution.

She repeated the experiment using 1.0 g, 1.5 g and 2.0 g of magnesium powder.



The diagrams of the thermometer show the highest temperature, in °C, reached in each of the experiments.



(a) Use the thermometer readings to complete the table of results.

(2)

Mass of magnesium in g	Initial temperature in °C	Highest temperature in °C	Temperature rise in °C
0.5	25		
1.0	24		
1.5	23		
2.0	23		

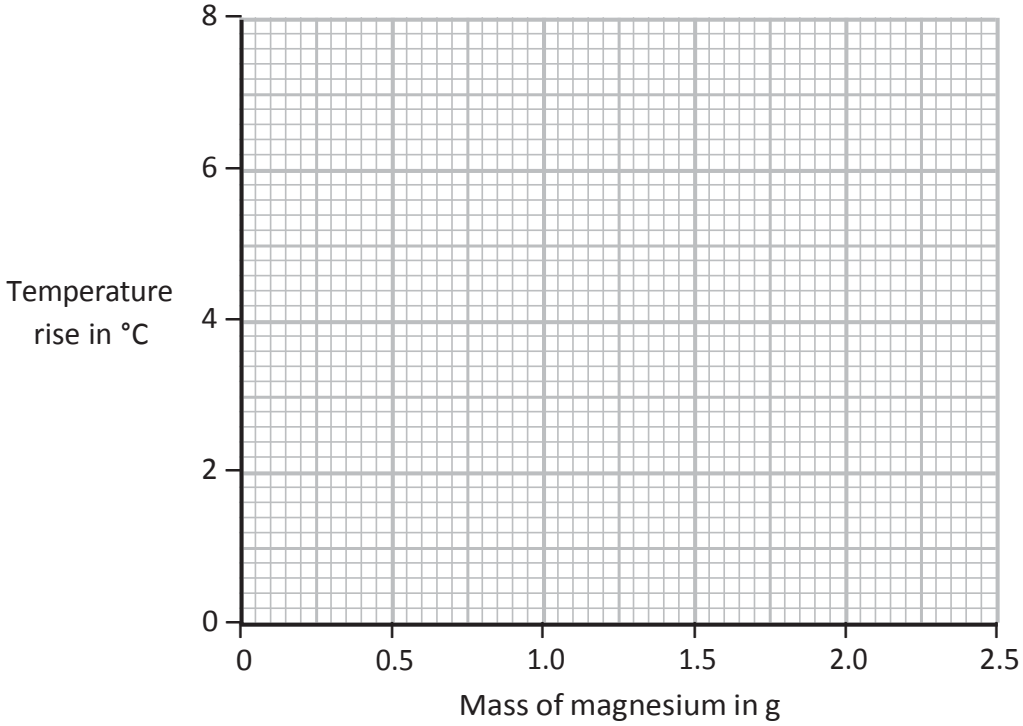
(b) A second student carried out the experiment. The table shows his results.

Mass of magnesium in g	Temperature rise in °C
0.5	2
1.0	4
1.5	6
2.0	6
2.5	6

(i) Plot the points on the grid.

Draw a straight line through the first three points and another straight line through the last two points. Make sure that the two lines cross.

(3)



(ii) Use your graph to find the mass of magnesium required to produce a temperature rise of 3 °C.

(1)

.....

(c) Suggest why the last three temperature rises were the same.

(1)

.....

(d) State and explain the effect on the temperature rises if the student were to repeat the experiment using the same masses of zinc powder instead of magnesium powder.

Do not refer to the difference in reactivity of the two metals.

[relative atomic masses: Mg = 24; Zn = 65]

(2)

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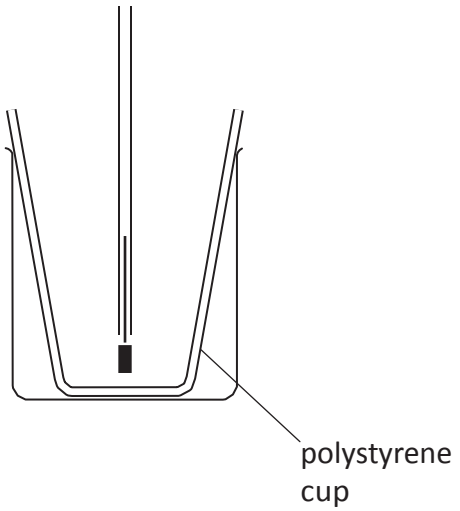
(Total for Question 2 = 9 marks)

3 A student investigated the neutralisation of acids by measuring the temperature changes when alkalis were added to acids of known concentrations.

He used this apparatus to add different volumes of sodium hydroxide solution to a fixed volume of dilute nitric acid.



He used this method.

- measure the temperature of 25.0 cm^3 of the acid in the polystyrene cup
- add the sodium hydroxide solution in 5.0 cm^3 portions until a total of 30.0 cm^3 has been added

(a) State two properties of the sodium hydroxide solution that should be kept constant for each 5.0 cm^3 portion.

(2)

1 .....

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2 .....

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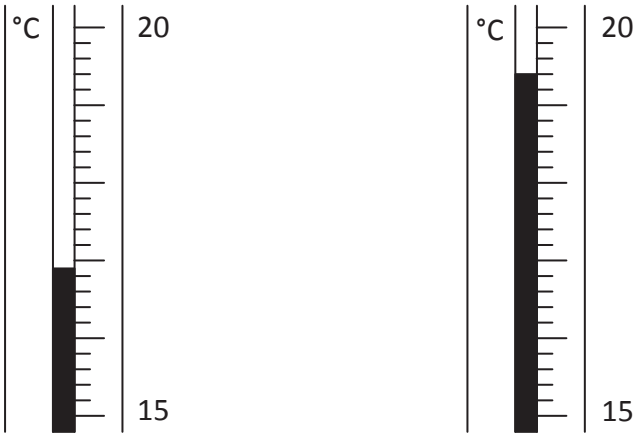
(b) The diagram shows the thermometer readings in one experiment.



before adding alkali after adding alkali

Write down the thermometer readings and calculate the temperature change.

(3)

temperature after adding alkali ..... °C

temperature before adding alkali ..... °C

temperature change ..... °C

(c) The student carried out the experiment three times.

The table shows his results.

Volume of alkali added in cm^3	Temperature in °C		
	experiment 1	experiment 2	experiment 3
0.0	17.4	16.6	15.9
5.0	18.5	21.0	18.0
10.0	19.6	24.5	20.0
15.0	20.5	23.6	22.2
20.0	21.4	22.7	23.6
25.0	22.5	21.4	22.8
30.0	23.4	20.5	22.0

The teacher said that only the results for experiment 3 showed the expected increase and decrease in temperature.

(i) Why was there no temperature decrease in experiment 1?

(1)

☒ **A** The alkali was added too quickly

☒ **B** The starting temperature of the acid was too high

☒ **C** The acid concentration was half what it should have been

☒ **D** The volume of acid used was 50.0 cm^3 instead of 25.0 cm^3

(ii) Why were the temperature increases in experiment 2 much greater than expected?

(1)

☒ **A** The starting temperature of the acid was too high

☒ **B** The acid concentration was double what it should have been

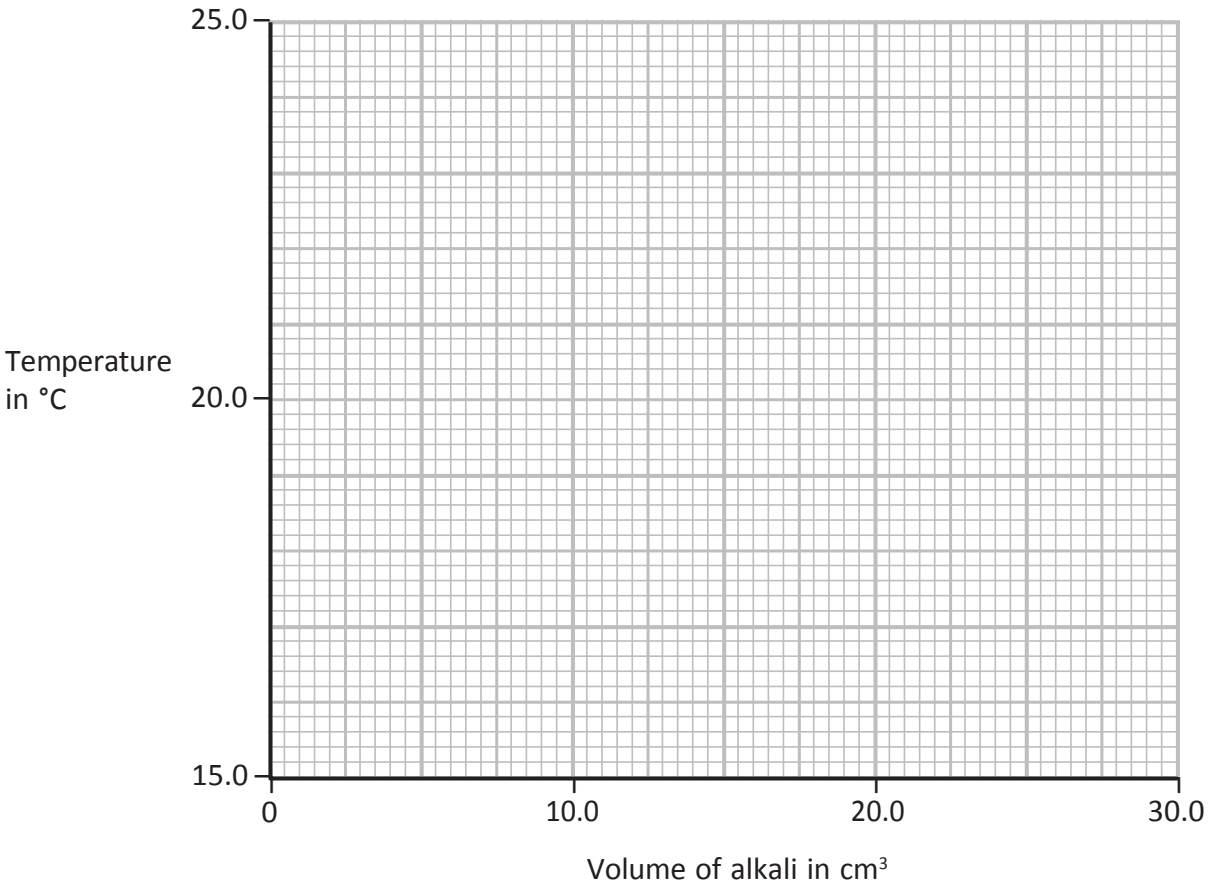
☒ **C** The volume of acid used was 50.0 cm^3 instead of 25.0 cm^3

☒ **D** The alkali was added in 10.0 cm^3 portions but were recorded as 5.0 cm^3 portions

(d) Plot the results of experiment 3 on the grid.

Draw a straight line of best fit through the first four points, and another straight line of best fit through the last three points. Make sure that the two lines cross.

(4)



(e) The point where the lines cross indicates the volume of alkali added to exactly neutralise the acid and also the maximum temperature reached.

Record these values.

(2)

volume of alkali ..... cm^3

maximum temperature ..... °C

(f)) Another student used sulfuric acid instead of nitric acid in her experiments. She started with 25.0 cm^3 of sulfuric acid of concentration 0.650 mol/dm^3.

She added 0.500 mol/dm^3 sodium hydroxide solution until the acid was completely neutralised.

The equation for this reaction is

$$2NaOH + H_2SO_4 \rightarrow Na_2SO_4 + 2H_2O$$

(i) Calculate the amount, in moles, of sulfuric acid used. **(2)**

amount = ... mol

(ii) Calculate the amount, in moles, of sodium hydroxide needed to neutralise this amount of sulfuric acid.

(1)

amount = ... mol

(iii) Calculate the volume, in cm^3, of sodium hydroxide solution needed to neutralise this amount of sulfuric acid.

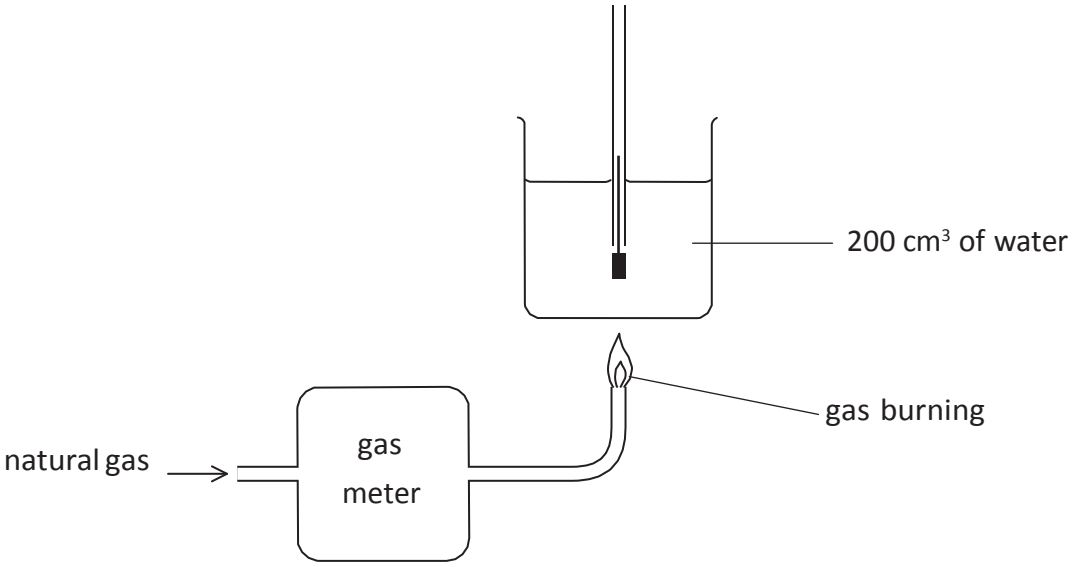
(2)

volume = ... cm^3

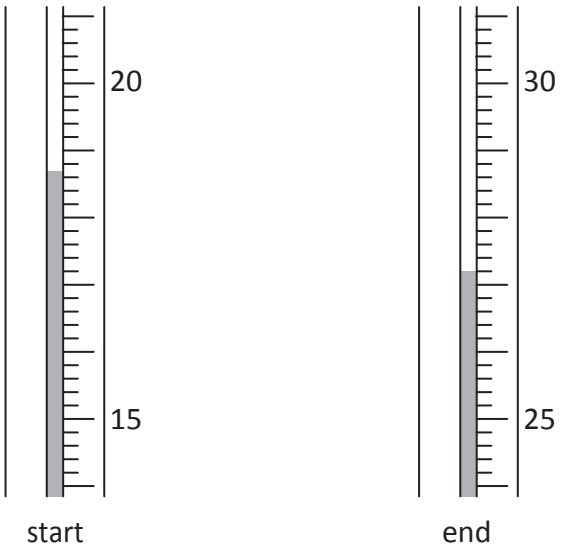
(Total for Question 3 = 18 marks)

4 A student does some experiments to find the heat energy released when natural gas burns.

She uses this apparatus.



(a) The diagram shows the thermometer readings in one of her experiments.



Use these readings to complete the table, entering all values to the nearest 0.1 °C.

(3)

temperature of water at start in °C	
temperature of water at end in °C	
temperature change in °C	

(b) The student repeats the experiment three times.

The table shows her results.

Experiment	Volume of gas burned in cm^3	Temperature rise of water in °C
1	1450	34.8
2	1875	41.2
3	1620	37.7

(i) Calculate the amount, in moles, at room temperature and pressure, of methane burned in experiment 1.

Assume that natural gas contains only methane.

(The volume of 1 mol of a gas at room temperature and pressure is 24 000 cm^3)

(2)

amount = ... mol

(ii) The quantity of heat energy released in experiment 1 is 29 200 J.

Calculate the molar enthalpy change, in kJ/mol, for the combustion of methane.

(2)

molar enthalpy change = ... kJ/mol

(iii) The temperature rise in experiment 2 is 41.2 °C.

Calculate the heat energy change in experiment 2 using the expression

heat energy change = volume of water × 4.2 × temperature change
(in J) (in cm^3) (in °C)

(2)

heat energy change = ... J

(iv) The student uses the results from experiment 3 to calculate the molar enthalpy change, in kJ/mol, for the combustion of methane.

She compares her value with the value in a data book.

student's value	$\Delta H = -510$ kJ/mol
data book value	$\Delta H = -890$ kJ/mol

Which is the best explanation for the large difference between these two values?

(1)

A natural gas contains other gases that release heat energy when burned

B not all of the heat energy is transferred to the water

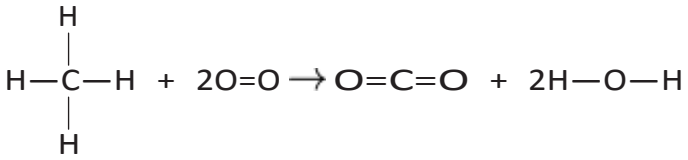
C some of the water evaporates during the experiment

D the student measures the gas by volume instead of by mass

(c) The student uses a table of average bond energies to calculate another value for the molar enthalpy of combustion of methane.

Bond	C—H	O=O	C=O	H—O
Average bond energy in kJ/mol	412	496	743	463

The equation for the combustion can be shown using displayed formulae.



(i) Use values from the table to calculate the energy taken in when the bonds in the reactants are broken.

(2)

energy taken in = ... kJ

(ii) Use values from the table to calculate the energy given out when the bonds in the products are formed.

(2)

energy given out = ... kJ

(iii) Use your answers to (i) and (ii) to calculate the molar enthalpy change for the combustion of methane.

(1)

molar enthalpy change = ... kJ/mol

(Total for Question 4 = 15 marks)