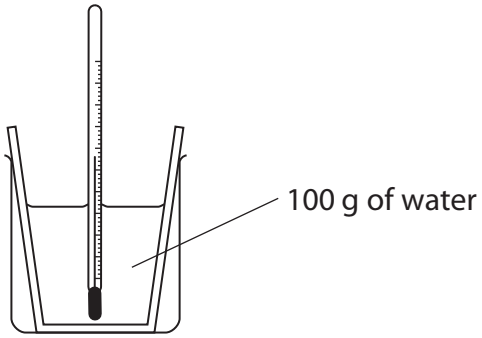
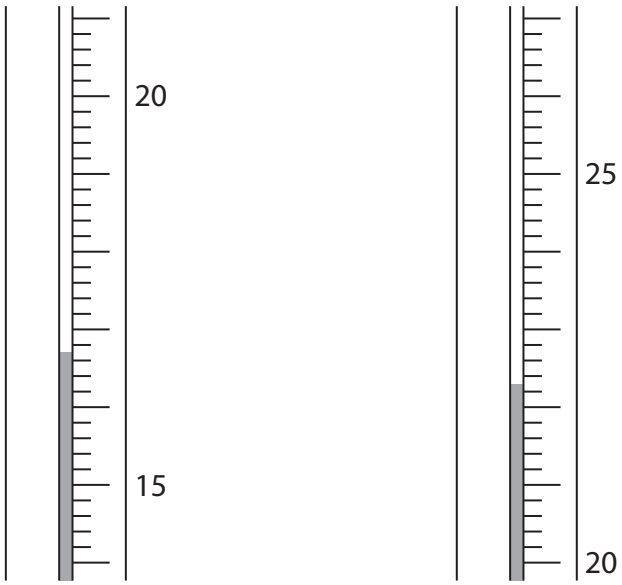
1 A student uses this apparatus to measure the temperature change when lithium iodide dissolves in water.



He measures the steady temperature of the water before adding the lithium iodide.

He then adds the lithium iodide, stirs the mixture until all the solid dissolves and records the maximum temperature reached.

The diagram shows the thermometer readings before and after dissolving the lithium iodide.



(a) Use the readings to complete the table.

(3)

Temperature in °C after adding lithium iodide	
Temperature in °C before adding lithium iodide	
Temperature change in °C	

(b) In a second experiment, using the same mass of water, the student records a temperature increase of 4.9 °C.

(i) Use this expression to calculate the heat energy change in this experiment.

heat energy change (in joules) = mass of water (in grams) × 4.2 × temperature change (in °C)

(2)

heat energy change = ... J

(ii) In this experiment, 6.3 g of lithium iodide were used.

Calculate the amount, in moles, of lithium iodide in 6.3 g.

[M_r of lithium iodide = 134]

(2)

amount of LiI = ... mol

(c) In a third experiment the student obtains these results.

heat energy change in J	2400
amount of lithium iodide in mol	0.048

(i) Calculate the molar enthalpy change, in kJ/mol, in this experiment.

(2)

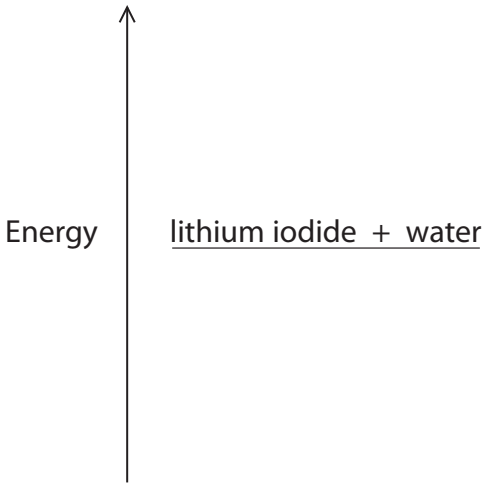
molar enthalpy change = ... kJ/mol

(ii) The temperature change in this experiment shows that dissolving lithium iodide in water to form lithium iodide solution is an exothermic process.

Complete the energy level diagram to show the position of the lithium iodide solution.

Label the diagram to show ΔH, the molar enthalpy change.

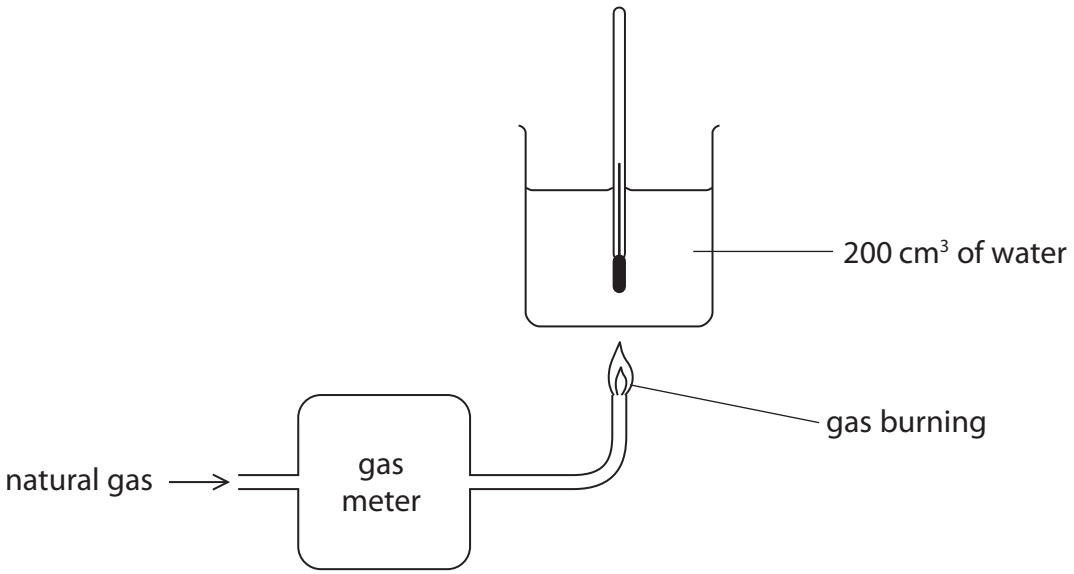
(2)



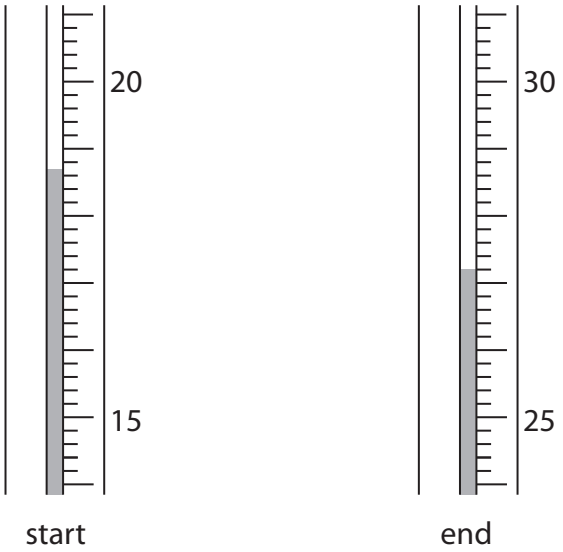
(Total for Question 1 = 11 marks)

2 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) (i °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

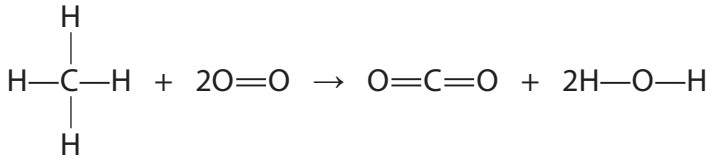
☒ **C** some of the water evaporates during the experiment

☒ **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

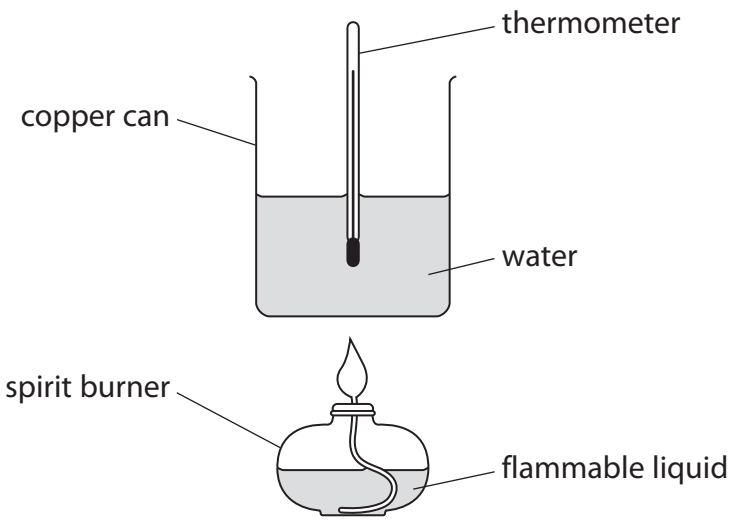
(iii) Use your answers to (i) and (ii) to calculate the molar enthalpy change for the combustion of methane.

(1)

molar enthalpy change = ... kJ/mol

(Total for Question 2 = 15 marks)

3 A student investigates the temperature rise of water in a copper can placed above a spirit burner containing a flammable liquid. The diagram shows the apparatus he uses.



This is the student's method.

- place 200 g of water in the copper can and record the temperature of the water
- weigh the spirit burner containing the flammable liquid
- place the spirit burner underneath the copper can and light the burner
- after two minutes extinguish the flame and record the maximum temperature of the water
- reweigh the spirit burner containing the remaining flammable liquid

(a) State whether each of the changes listed in the table would increase, decrease or have no effect on the value of the maximum temperature of the water.

(3)

Change	Effect on the value of the maximum temperature of the water
increasing the distance between the spirit burner and the copper can	
using a thermometer with divisions at 0.2 °C instead of 0.5 °C	
adding insulation to the side of the copper can	

(b) In one experiment pentane was used as the flammable liquid. The calculated heat energy change was 51 900 J.

In the experiment the mass of pentane burned was 1.88 g.

The relative molecular mass of pentane is 72

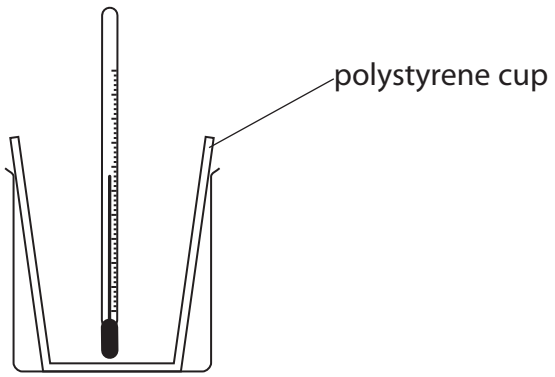
Use this information to calculate the molar enthalpy change of combustion, in kJ/mol, of pentane.

(3)

molar enthalpy change = ... kJ/mol

(Total for Question 3 = 6 marks)

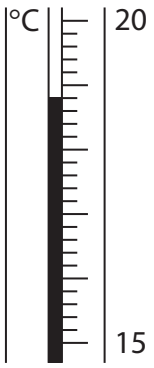
4 A student uses this apparatus to investigate the temperature change that occurs when potassium hydroxide is dissolved in water.



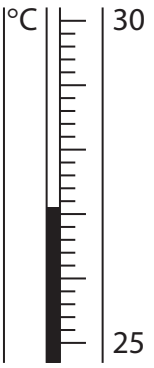
She uses this method.

- pour 50 cm^3 of water into the polystyrene cup and measure the temperature of the water
- add 3 g of potassium hydroxide and stir
- record the highest temperature of the solution

(a) These diagrams show the thermometer readings before and after the student added the potassium hydroxide.



before



after

Use the readings to complete the table.

(3)

temperature in °C after adding potassium hydroxide	
temperature in °C before adding potassium hydroxide	
temperature change in °C	

(b) The student uses her results to calculate the enthalpy change for dissolving potassium hydroxide in water.

She compares her value with a data book value.

Student's value = – 32 kJ/mol.

Data book value = – 55 kJ/mol.

There are no errors in the student's method or in the calculation.

Suggest two reasons why the student's value differs from the data book value.

(2)

1 .....

.....

.....

2 .....

.....

.....

(Total for Question 4 = 5 marks)