5.1 Energetics

Question Paper

Course	DP IB Chemistry
Section	5. Energetics / Thermochemistry
Topic	5.1 Energetics
Difficulty	Hard

Time allowed: 50

Score: /39

Percentage: /100

Question 1a

a)
When anhydrous copper(II) sulfate is left in the atmosphere it will slowly turn to a blue pentahydrate solid. It is possible to measure the heat changes directly when both anhydrous and pentahydrated copper(II) sulfate are **separately** dissolved in water.

i)
Write an equation for the reaction of anhydrous copper(II) sulfate with water to form pentahydrated copper(II) sulfate.

[1]

ii)
Construct an energy cycle which can be used to determine the enthalpy change indirectly.

[2]

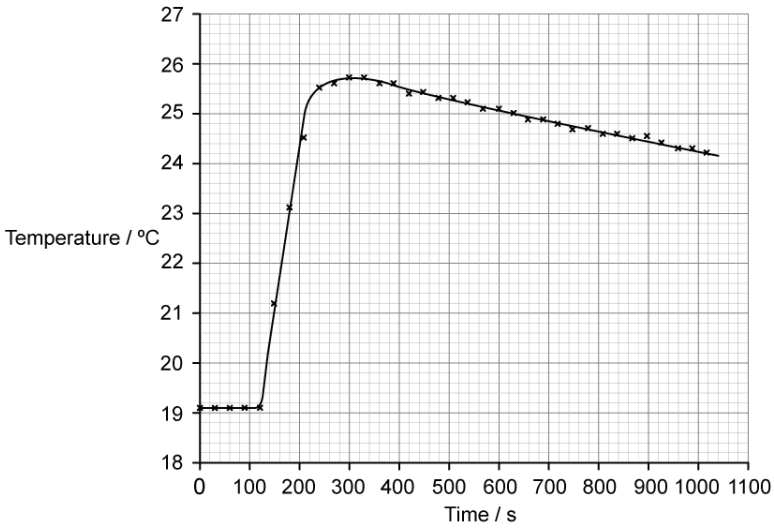
[3 marks]

Question 1b

b)

To determine the enthalpy change a student placed 50 cm^3 of water in a polystyrene cup and used a data logger to measure the temperature.

After two minutes she dissolved 6.30 g of anhydrous copper(II) sulfate in the water and continued to record the temperature while continuously stirring. She obtained the following results.



i)

Using section 6 in the data booklet, determine the amount, in moles, of copper(II) sulfate.

[1]

ii)

Determine the temperature change, in °C, for the reaction assuming no heat had been lost to the surroundings.

[1]

iii)

Using sections 1 and 2 in the data booklet, determine the heat change, in kJ mol^{-1}, for the reaction.

[2]

[4 marks]

Question 1c

c)
The student repeated the experiment using 7.83 g of pentahydrated copper(II) sulfate and observed the temperature decreased by 2.5 °C. The student used the same volume of water.

i)
Use section 6 of the data booklet to determine the amount, in moles, of pentahydrated copper(II) sulfate.

[1]

ii)
Use sections 1 and 2 in the data booklet to determine the heat change, in kJ mol^{-1}.

[2]

[3 marks]

Question 1d

d)
Use your answers to parts a), b) and c) to determine the energy change for dissolving copper(II) sulfate.

[2]

[2 marks]

Question 2a

a)
A student investigated the temperature change for the neutralisation of malonic acid, $HOOCCH_2COOH$, and sodium hydroxide solution.

25.0 cm^3 of 0.400 mol dm^{-3} of malonic acid was added to a beaker and the temperature was recorded every minute for three minutes using using a thermometer with an uncertainty of ±0.1° C. On the fourth minute the student added 50.0 cm^3 of 0.500 mol dm^{-3} sodium hydroxide solution.

Finally, she recorded the temperature every minute for eight minutes.

Determine the percentage uncertainty in the student's 2.9 °C temperature rise.

[2]

[2 marks]

Question 2b

b)
Another student completed the same investigation and recorded a maximum temperature of 23.5 °C. The student calculated the heat energy, *q*, for the reaction to be 8.923×10^{-1} kJ.

Use sections 1 and 2 in the data booklet and the information in part a) to estimate the initial temperature for this student's investigation.

[3]

[3 marks]

Question 2c

c)
State the balanced symbol equation for the neutralisation of malonic acid with sodium hydroxide solution.

[1]

[1 mark]

Question 2d

d)
The student determined that the enthalpy change of neutralisation, ΔH_{neut}, was -35.7 kJ mol^{-1}. Deduce if the student is correct and justify your answer.

[4]

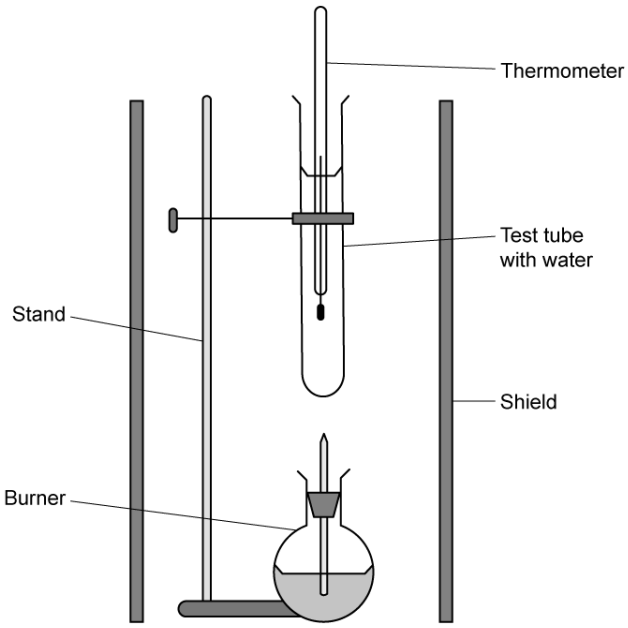
[4 marks]

Question 3a

a)

Ethanol is made in large quantities via the hydration of ethene in the presence of a concentrated phosphoric acid catalyst or via the fermentation of glucose. Ethanol is widely used as a fuel.

The enthalpy of combustion of ethanol can also be determined experimentally in a school laboratory. A burner containing ethanol was weighed and used to heat water in a test tube as illustrated below.



The following data was obtained from the combustion of ethanol.

Initial mass of burner and ethanol / g	76.137
Final mass of burner and ethanol / g	75.614
Volume of water in test tube / g	20.000
Initial temperature of water / °C	19.2
Final temperature of water / °C	24.3

i)

State the equation for the combustion of ethanol.

[2]

ii)

Using the information from Table 11 of the Data booklet, determine the theoretical enthalpy of combustion of ethanol.

[3]

[5 marks]

Question 3b

b)
Use the information in part a) and sections 1, 2 and 6 in the data booklet to determine.

i)
The amount, in moles, of ethanol burned.

[1]

ii)
The heat absorbed, in kJ, by the water.

[3]

iii)
The enthalpy change, in kJ mol^{-1}, for the combustion of 1 mole of ethanol.

[2]

[6 marks]

Question 3c

c)
Compare the data book value in section 13 with your answer to part b) and suggest why these values differ.

[1]

[1 mark]

Question 4a

a)
The enthalpy change of solution for lithium chloride can be measured using calorimetry.

The expected final temperature when 12.04 g of lithium chloride is dissolved in 20.0 cm^3 of water at 19.5 °C.

Use section 6 in the data booklet to determine the amount, in moles, of the lithium chloride dissolved.

[1]

[1 mark]

Question 4b

b)
Use your answer to part a) and section 19 in the data booklet to determine the energy released, in J, when 1.60 g of lithium chloride is dissolved in 20.0 cm^3 of water.

[1]

[1 mark]

Question 4c

c)
Use your answer to part b) and sections 1 and 2 in the data booklet, determine the change in temperature, in °C, when the lithium chloride is dissolved.

[2]

[2 marks]

Question 4d

d)
Use your answer to part c) determine the maximum temperature, in °C, of the solution that was reached during the reaction.

[1]

[1 mark]