Energetics

Question Paper

Level	International A Level
Subject	Chemistry
Exam Board	Edexcel
Topic	Chemistry Lab Skills 1
Sub Topic	Energetics
Booklet	Question Paper

Time Allowed: **54 minutes**

Score: **/45**

Percentage: **/100**

Grade Boundaries:

A*	A	B	C	D	E	U
>85%	'77.5%	70%	62.5%	57.5%	45%	<45%

1 The thermal decomposition of copper(II) carbonate is

$$CuCO_3(s) \rightarrow CuO(s) + CO_2(g) \qquad \textbf{Equation 3}$$

The enthalpy change for this reaction, ΔH_3, cannot be determined directly. However, it can be calculated using Hess's law, from the enthalpy changes for the reaction of sulfuric acid with copper(II) carbonate and with copper(II) oxide.

(a) A student carried out an experiment to determine the enthalpy change, ΔH_4, for the reaction

$$CuCO_3(s) + H_2SO_4(aq) \rightarrow CuSO_4(aq) + H_2O(l) + CO_2(g) \qquad \textbf{Equation 4}$$

In the experiment, a known mass of copper(II) carbonate was mixed with a known volume of sulfuric acid in a polystyrene cup, and the temperature change measured. The results of the experiment are shown in the table.

Measurement	Reading
Mass of copper(II) carbonate added to sulfuric acid	2.54 g
Volume of sulfuric acid, 1 mol dm^{-3}	50.0 cm^3
Initial temperature of sulfuric acid before addition of copper(II) carbonate	24.3°C
Maximum temperature of sulfuric acid after the addition of copper(II) carbonate	29.0°C

(i) Calculate the energy transferred, in joules, for this reaction using the expression

Energy transferred (J) = 50.0 × 4.18 × temperature change

(1)

(ii) Calculate the number of moles of copper(II) carbonate used.

Molar mass of copper(II) carbonate = 123.5 g mol^{-1}

(1)

(iii) Use your answers to (a)(i) and (a)(ii) to calculate, in kJ mol^{-1}, the enthalpy change, ΔH_4, for the reaction shown in **Equation 4**. Include a sign for ΔH_4 and give your answer to **three** significant figures.

(2)

(iv) Why does the sulfuric acid need to be in excess?

(1)

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(v) The enthalpy change obtained from this experiment is much less negative than the Data Booklet value.

Suggest one likely reason for this difference, other than a measurement error.

(1)

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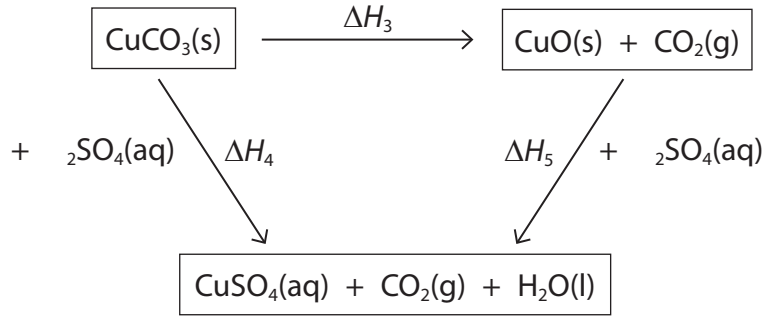
(b) The student then carried out a similar experiment to determine the enthalpy change, ΔH_5, for the reaction between copper(II) oxide and sulfuric acid.

$$CuO(s) + H_2SO_4(aq) \rightarrow CuSO_4(aq) + H_2O(l)$$ **Equation 5**

From the results of this experiment, ΔH_5 was calculated to be –56.1 kJ mol^{-1}.

The values of ΔH_4 and ΔH_5 can be used to determine the enthalpy change for the thermal decomposition of copper(II) carbonate using the Hess cycle shown below.



Use Hess's law to calculate the value of ΔH_3, in kJ mol^{-1}. Include a sign in your answer.

(2)

(c) Suggest why it is not possible to determine directly the enthalpy change for the thermal decomposition of copper(II) carbonate.

(1)

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(Total for Question 1 = 9 marks)

2 This question is about enthalpy changes which occur on dissolving different substances.

(a) The enthalpy change which occurs when solid ammonium chloride, NH_4Cl, dissolves in water was found using the method below.

25.0 cm^3 of water was measured using a burette and put into a small beaker. The temperature of the water was measured.

5.00 g of powdered ammonium chloride was added to the water, the mixture was stirred continuously and the lowest temperature of the resulting solution was recorded.

Results:

Initial temperature of water = 22.0 °C

Lowest recorded temperature = 11.5 °C

(i) Calculate the energy transferred when 5.00 g of ammonium chloride dissolves in 25.0 cm^3 of water.

Hence calculate the enthalpy change, $\Delta H_{solution}$, which occurs when 1 mol of ammonium chloride dissolves in water.

Give your final answer to **three** significant figures and include a sign and units.

Use the equation:

Energy transferred (J) = mass of water × 4.18 × temperature change.

The density of water is 1.00 g cm^{-3}

(3)

(ii) The thermometer used in this experiment gave a total uncertainty in the temperature measurement of just under ±5%.

The mass of ammonium chloride was measured using a balance which had an uncertainty of ±0.005 g in each reading.

Show by calculation that the uncertainty of the result of the experiment would not be improved significantly if a more precise balance was used.

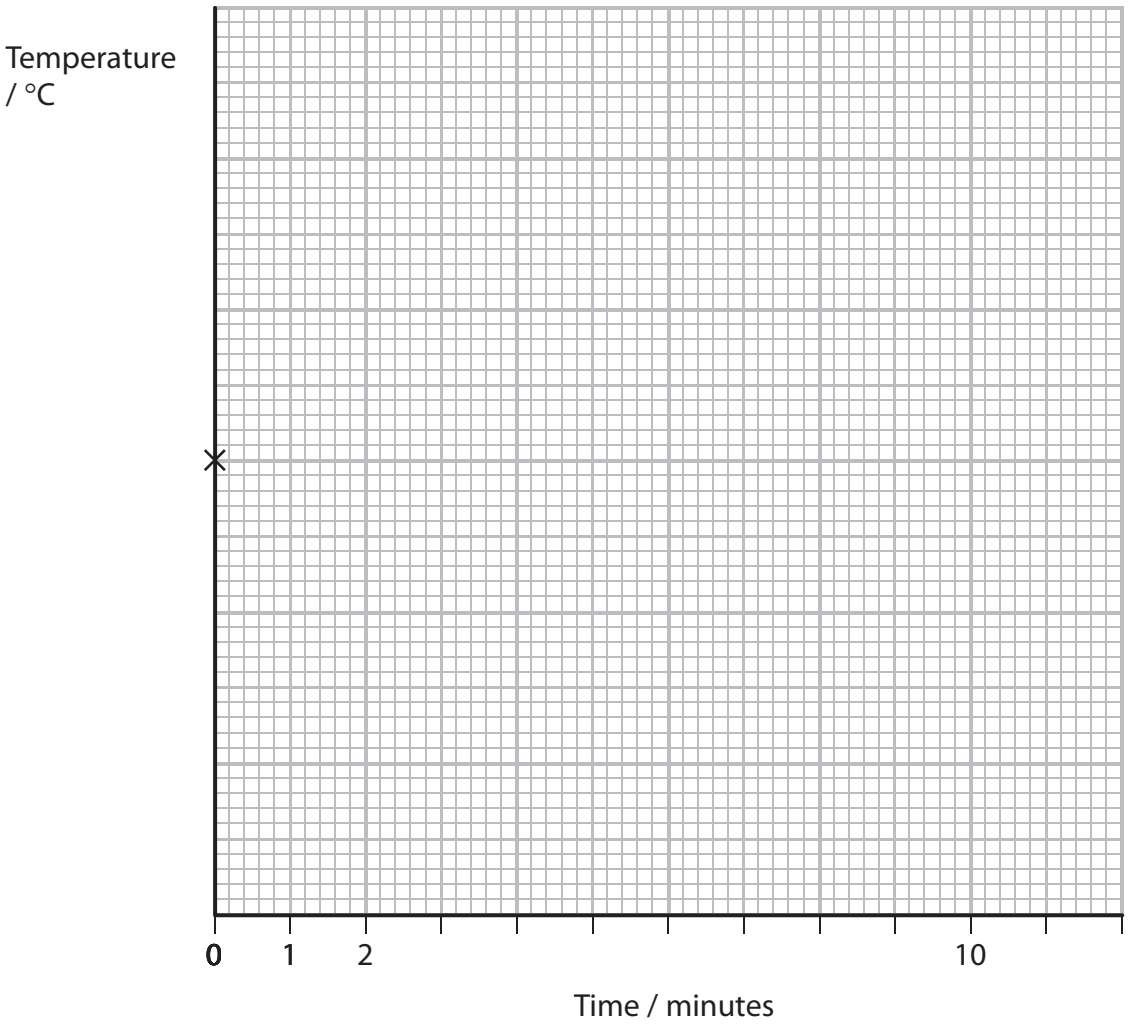
(2)

(b) In order to determine a more accurate value for the temperature change, the experiment in (a) was repeated with some modifications to the procedure.

The temperature of the water was measured as a stop clock was started, and again after one minute and two minutes. Three minutes after starting the clock, the ammonium chloride was added to the water. The temperature was then read each minute from the fourth to the tenth minute, while stirring the mixture continuously.

(i) On the grid below, mark where you would expect to find the points when the temperature measurements are plotted against time. The initial temperature has been plotted for you. You are **not** expected to plot the position of the points accurately; simply indicate their approximate position relative to the starting point.

(2)



(ii) On the grid, draw the lines needed to determine the maximum temperature change. Add a label to show the maximum temperature change on the graph.

(2)

(iii) A student carried out the experiment using water from a tap. What is the purpose of measuring the temperature of the water at 0, 1 and 2 minutes from the time of starting the clock?

(1)

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(c) The equation for the thermal decomposition of ammonium chloride is shown below.

$$NH_4Cl(s) \rightarrow NH_3(g) + HCl(g)$$

(i) Suggest why the enthalpy change for this reaction, $\Delta H_{reaction}$, is difficult to determine directly by experiment.

(1)

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(ii) Some enthalpy changes which can be determined experimentally are listed below.

$NH_4Cl(s) + water \rightarrow NH_4Cl(aq)$ ΔH_1

$NH_3(g) + water \rightarrow NH_3(aq)$ ΔH_2

$HCl(g) + water \rightarrow HCl(aq)$ ΔH_3

$NH_3(aq) + HCl(aq) \rightarrow NH_4Cl(aq)$ ΔH_4

By adding arrows to the diagram below, construct a Hess cycle which can be used to calculate the enthalpy change, $\Delta H_{reaction}$, for the thermal decomposition of ammonium chloride.

Label each arrow with the appropriate symbol chosen from the list above for the enthalpy change. Assume that water is added where necessary to make a solution.

(1)

(iii) Give the expression for the enthalpy change, $\Delta H_{reaction}$, for the thermal decomposition of ammonium chloride, in terms of the other enthalpy changes in the cycle.

(1)

$\Delta H_{reaction} =$

(Total for Question 2 = 13 marks)