UNIVERSITY OF CAMBRIDGE INTERNATIONAL EXAMINATIONS
General Certificate of Education Advanced Level

CANDIDATE NAME	

CENTRE NUMBER		CANDIDATE NUMBER	

CHEMISTRY **9701/51**

Paper 5 Planning, Analysis and Evaluation **May/June 2010**

1 hour 15 minutes

Candidates answer on the Question Paper.

No Additional Materials are required.

READ THESE INSTRUCTIONS FIRST

Write your Centre number, candidate number and name on all the work you hand in.
Write in dark blue or black pen.
You may use a soft pencil for any diagrams, graphs or rough working.
Do not use staples, paper clips, highlighters, glue or correction fluid.
DO **NOT** WRITE IN ANY BARCODES.

Answer **all** questions.
You may lose marks if you do not show your working or if you do not use appropriate units.
Use of a Data Booklet is unnecessary.

At the end of the examination, fasten all your work securely together.
The number of marks is given in brackets [ ] at the end of each question or part question.

For Examiner's Use	
1	
2	
3	
Total	

This document consists of **12** printed pages and **4** blank pages.

DC (AT/KN) 11584/3

UNIVERSITY *of* CAMBRIDGE International Examinations

1 The neutralisation of an acid by a base is exothermic.

In this experiment the following solutions are available.

2 mol dm^{-3} sulfuric acid, H_2SO_4
3 mol dm^{-3} sodium hydroxide, NaOH

The equation for the reaction is:

$$2NaOH(aq) + H_2SO_4(aq) \longrightarrow Na_2SO_4(aq) + 2H_2O(l)$$

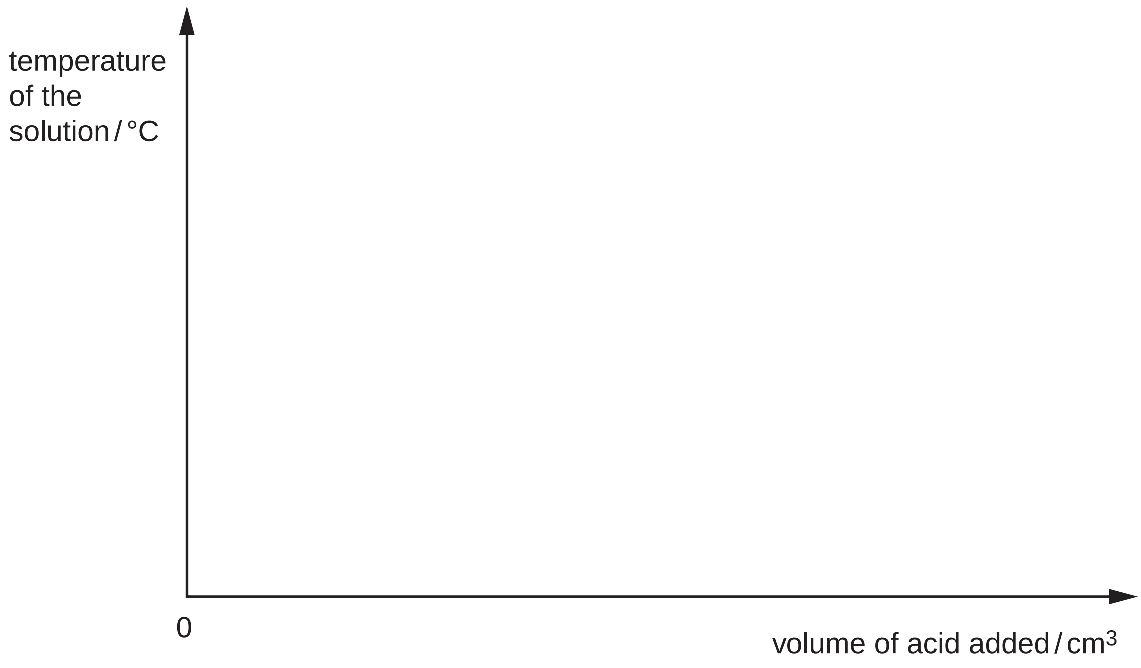
(a) 2 mol dm^{-3} H_2SO_4 is gradually added to a fixed volume of 3 mol dm^{-3} NaOH in a 150 cm^3 plastic cup, while stirring continuously. The temperature of the solution, measured with a thermometer, increases until the alkali is just neutralised. On further addition of the cold acid the temperature of the solution slowly falls.

Select an appropriate volume, $\boldsymbol{x}$ cm^3, of 3 mol dm^{-3} NaOH to use in the experiment.

.... cm^3

Calculate the volume of 2 mol dm^{-3} H_2SO_4 that will just neutralise $\boldsymbol{x}$ cm^3 of 3 mol dm^{-3} NaOH.

Sketch the graph you would expect to obtain as the acid is added.
Label the neutralisation point.



[3]

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(b) This experiment can be used to determine the enthalpy change of neutralisation for the reaction. To ensure reliable results the experiment should be repeated a number of times.

When sulfuric acid is added to the fixed volume of aqueous sodium hydroxide in this experiment

(i) the independent variable is .... ,

(ii) the dependent variable is .... ,

(iii) the other variables that need to be controlled are ....

....

[3]

(c) In carrying out the experiment, what apparatus would you use to accurately measure the independent variable?

....[1]

(d) Explain how you would use this apparatus to control the independent variable.

....

....[1]

(e) Identify and assess

(i) a risk associated with the plastic cup used in this experiment,

....

....

(ii) a risk associated with the 3 mol dm^{-3} NaOH.

....

....

[1]

(f) Describe how the risks in **(e)** can be kept to a minimum for

(i) the plastic cup,

....

....

(ii) the 3 mol dm^{-3} NaOH.

....

....
[1]

(g) In the space below draw a table to show column headings for all of the measurements you would make during the experiment.
Include in the table one or more columns for any calculated values needed to determine the enthalpy change of neutralisation.

[2]

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(h) Show how you would calculate the total heat energy produced in the plastic cup up to the point when the sulfuric acid has just neutralised the sodium hydroxide.
You may use ΔT to represent the temperature change.

[4.3 J of heat energy raise the temperature of 1 cm^3 of any solution by 1 °C.]

[1]

(i) The enthalpy change of neutralisation is the energy change associated with the reaction shown by the following equation.

$$NaOH(aq) + \tfrac{1}{2} H_2SO_4(aq) \longrightarrow \tfrac{1}{2} Na_2SO_4(aq) + H_2O(l)$$

Show how you would convert the energy change expressed in **(h)** into a value, in $kJ\,mol^{-1}$, for the enthalpy change of neutralisation, $\Delta H_{neutralisation}$.
Show clearly the sign and the expression for the enthalpy change.

$\Delta H_{neutralisation}$ = ... (*sign*) .... (*expression*) $kJ\,mol^{-1}$ [2]

[Total: 15]

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2 A student reads in a text-book about ideal and non-ideal mixtures of liquids.

> When two different liquids are mixed, bonds between molecules in each of the different liquids are broken and new bonds are formed between the different molecules in the mixture.
>
> In an ideal mixture the energy used to break bonds between molecules in the different liquids is approximately the same as the energy released when new bonds are formed between molecules in the mixture.
>
> In a non-ideal mixture the energy used to break bonds in the different liquids is **not** the same as that released in bond formation.
>
> The breaking of bonds is an endothermic process.
> The formation of bonds is an exothermic process.

In order to test this information, the student investigates a number of mixtures of

(i) propan-1-ol, $CH_3CH_2CH_2OH$, and propan-2-ol, $CH_3CHOHCH_3$,
(ii) ethanol, CH_3CH_2OH, and cyclohexane, C_6H_{12}.

The boiling point of each pure liquid and each mixture is measured. The thermometer used has graduations at 0.2 °C.

The results for the experiment with propan-1-ol and propan-2-ol, which was carried out four times, are shown on the next page.

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volume / cm^3		temperature of boiling mixture / °C				% (by volume) of propan-1-ol in mixture	mean boiling temperature / °C
propan-1-ol	propan-2-ol	1	2	3	4		
0	20.00	82.1	82.6	82.7	82.2		
4.00	16.00	85.3	85.4	85.5	85.4		
8.00	12.00	88.5	88.4	88.1	88.2		
12.00	8.00	91.3	90.6	91.2	91.4		
16.00	4.00	94.2	94.0	94.3	94.3		
20.00	0	97.1	97.3	97.2	97.8		

(a) Indicate below any results that you consider to be anomalies and that should not be included when calculating the mean boiling temperature.

....

....
[1]

(b) Complete the table above to show the following.

(i) the percentage (%) by volume of **propan-1-ol** in each of the liquids / mixtures

(ii) the mean boiling temperature for each of the liquids/mixtures

[2]

The experiment is repeated using mixtures of ethanol and cyclohexane. The results of these experiments are given in the table below.

volume / cm^3		% (by volume) of ethanol in mixture	mean boiling temperature / °C
ethanol	cyclohexane		
0	20.00	0	81.4
2.00	18.00	10.0	66.5
6.00	14.00	30.0	65.0
10.00	10.00	50.0	65.3
14.00	6.00	70.0	65.5
18.00	2.00	90.0	68.0
20.00	0	100.0	78.5

(c) For both graphs below, use as much of the *y*-axis as possible for experimental data. Do **not** start your temperature scales at 0 °C.
Draw a graph of mean boiling temperature (*y*-axis) against the % of propan-1-ol (*x*-axis) in the mixture of propan-1-ol and propan-2-ol.

Draw a graph of mean boiling temperature (*y*-axis) against the % of ethanol (*x*-axis) in the mixture of ethanol and cyclohexane.

[3]

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(d) The graph you have drawn for propan-1-ol and propan-2-ol is typical of ideal mixtures of liquids.
The graph you have drawn for ethanol and cyclohexane is typical of some non-ideal mixtures of liquids.

From the shape of your graph explain whether the mixing of ethanol and cyclohexane is overall an endothermic or an exothermic process.

The mixing of ethanol and cyclohexane is .... ,

because ....

....

....

What type of intermolecular forces exist between the molecules of

(i) pure ethanol, ...

....

(ii) pure cyclohexane, ...

....

(iii) ethanol and cyclohexane in the mixture?

....
[3]

[Total: 9]

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3 A group of students perform an experiment to confirm that the formula of magnesium oxide is MgO. Each student is provided with a different length of magnesium ribbon which is coiled and heated in a crucible fitted with a lid. The magnesium reacts with oxygen to form magnesium oxide.

The instructions for the experiment are as follows.

- Weigh the empty crucible and lid.
- Coil the length of magnesium ribbon and place it in the bottom of the crucible.
- Reweigh the crucible and lid with the magnesium.
- Heat the crucible with a Bunsen burner.
- Periodically lift the crucible lid for a very short period of time. This allows air to enter the crucible.
- Each time the lid is lifted, take care to minimise the loss of any white smoke which is some of the powder formed.
- When the reaction appears to have stopped, remove the crucible lid and heat the crucible and its contents strongly for 2 minutes.
- Cool and reweigh the crucible, lid and the contents.

The results of the experiment are given below.

student	mass of crucible and lid / g	mass of crucible and lid + magnesium / g	mass of crucible and lid + magnesium oxide / g	mass of magnesium / g	mass of magnesium oxide / g
1	25.37	26.62	27.50		
2	25.18	27.01	28.19	1.83	3.01
3	25.44	27.73	29.19	2.29	3.75
4	25.26	27.71	24.96	2.45	
5	25.39	28.11	29.84	2.72	4.45
6	25.04	27.89	28.54	2.85	3.50
7	25.13	28.08	29.93		

(a) Complete the table above for student 1, student 4 and student 7.

Plot the data for student 1 and for student 7 on the graph on the next page.

[1]

(b) If the formula of magnesium oxide is MgO, the straight line indicates the mass of magnesium oxide formed from a given mass of magnesium.

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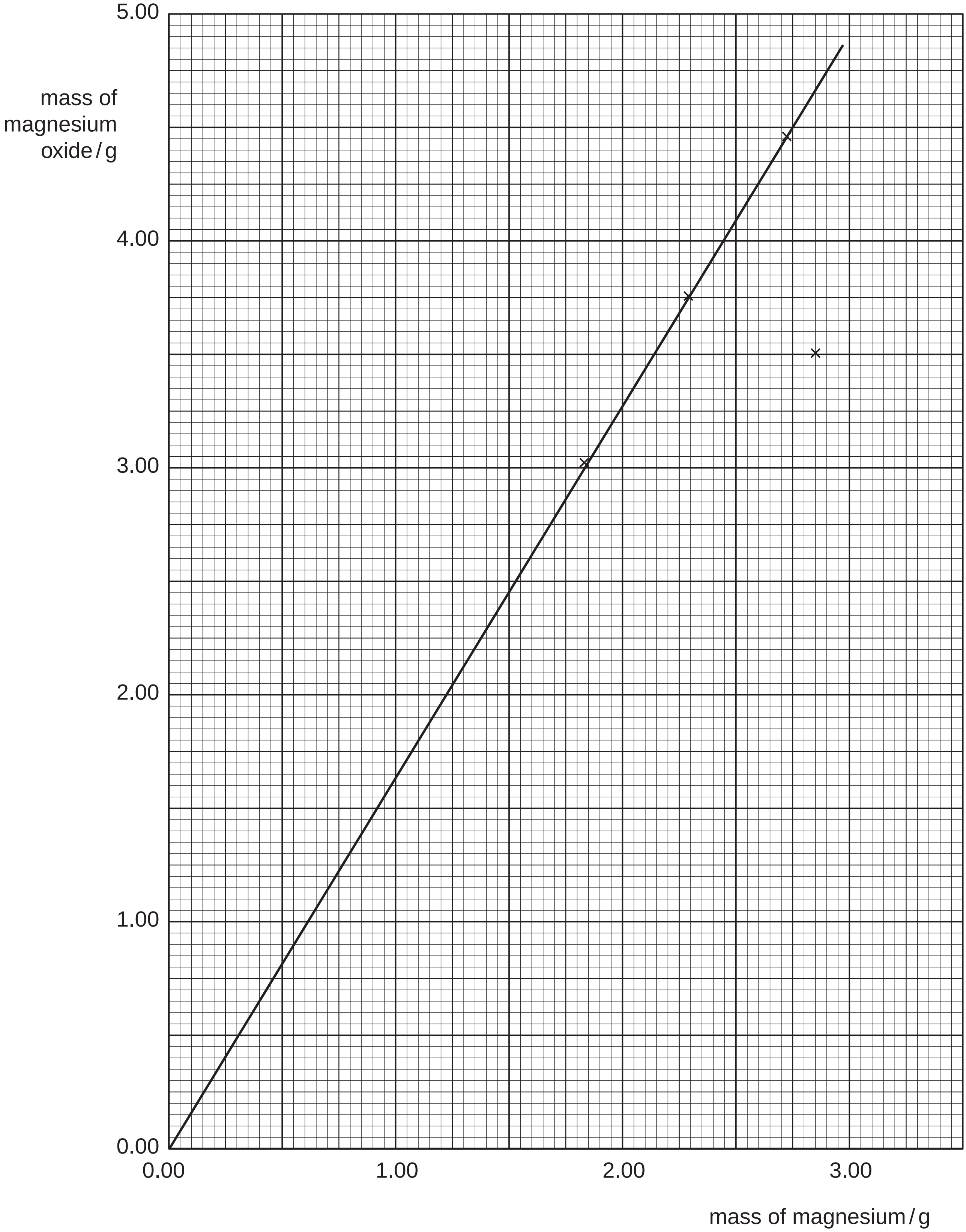

Choose a mass of Mg and use the straight line to determine the corresponding mass of MgO formed.

.... g of magnesium form .... g of magnesium oxide. [1]

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(c) Show by calculation that the masses of magnesium and magnesium oxide selected in **(b)** correspond to a formula of MgO.
[A_r: O,16.0; Mg, 24.3]

[1]

(d) The point plotted for student 6 shows a large deviation from the straight line.
Refer to the instructions for the experiment and suggest a possible explanation for this anomalous result.

....

....

....[1]

(e) The result for student 4 could not be plotted on the graph. Suggest an error in carrying out the experiment that could have led to this result.

....

....

....[1]

(f) Student 1 added a few drops of water to the cooled residue in the crucible.
The residue and water reacted to produce ammonia gas, NH_3.
Explain why this observation reduces confidence in this experiment as a method for determining the formula of magnesium oxide.

....

....

....[1]

[Total: 6]

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