UNIVERSITY OF CAMBRIDGE INTERNATIONAL EXAMINATIONS
General Certificate of Education Advanced Subsidiary Level and Advanced Level

CANDIDATE NAME									
CENTRE NUMBER						CANDIDATE NUMBER				

4533287500

CHEMISTRY **9701/05**

Paper 5 Planning, analysis and evaluation **May/June 2008**

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 are advised to show all working in calculations.
Use of 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	
Total	

This document consists of **11** printed pages and **1** blank page.

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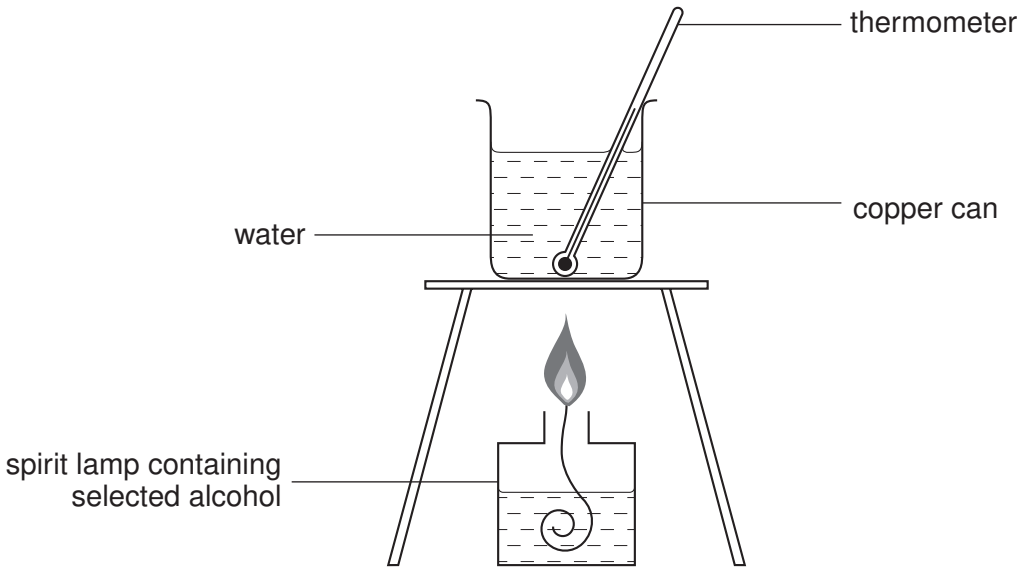
1 The equations for the complete combustion of the first five members of the alcohol homologous series are shown below.

methanol	$CH_3OH(l) + 1\frac{1}{2}O_2(g) \longrightarrow CO_2(g) + 2H_2O(l)$
ethanol	$CH_3CH_2OH(l) + 3O_2(g) \longrightarrow 2CO_2(g) + 3H_2O(l)$
propan-1-ol	$CH_3CH_2CH_2OH(l) + 4\frac{1}{2}O_2(g) \longrightarrow 3CO_2(g) + 4H_2O(l)$
butan-1-ol	$CH_3CH_2CH_2CH_2OH(l) + 6O_2(g) \longrightarrow 4CO_2(g) + 5H_2O(l)$
pentan-1-ol	$CH_3CH_2CH_2CH_2CH_2OH(l) + 7\frac{1}{2}O_2(g) \longrightarrow 5CO_2(g) + 6H_2O(l)$

You are to plan an experiment to determine the enthalpy change of combustion under laboratory conditions, ΔH_c, for each of the five alcohols using the apparatus and information below.



[4.2 J of heat energy raise the temperature of 1 cm^3 (1 g) of water by 1 °C.]

(a) Inspection of the products of the five equations shows that from ethanol to pentan-1-ol each equation has one more mole of CO_2 and one more mole of H_2O produced per mole of alcohol than the equation above it.

What difference between the structures of adjacent alcohols is responsible for these additional combustion products?

.....[1]

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(b) There is a trend in ΔH_c for these five alcohols. Use your answer to **(a)** to sketch the trend indicated by the equations.

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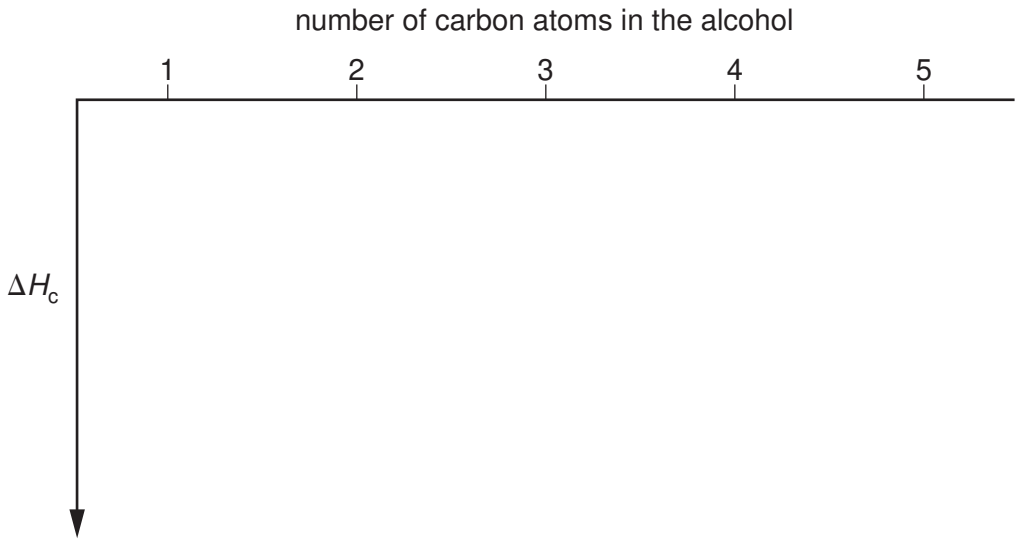

[1]

(c) Identify each of the following variables in the experiment to determine the enthalpy change of combustion of an alcohol using the apparatus in the diagram.

The independent variable is ……..

The dependent variable is …….

Two variables to be controlled in this experiment are

1 .....

2 .....

[3]

(d) You are to plan a step-by-step method to determine the enthalpy change of combustion, ΔH_c, for each of the alcohols in turn. You should use the apparatus shown in the diagram on page 2 and any other apparatus required that is normally found in a school or college laboratory.

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You need only explain how the method will be used for ethanol.

Your method should cover the following points.

- the precision of the apparatus to be used
- the way in which the independent variable is varied between experiments
- measurement of the dependent variable
- appropriate quantities to be used
- the raw data to be collected
- how this data is to be processed for ethanol

[4.2 J of heat energy raise the temperature of 1 cm^3 (1 g) of water by 1 °C.]

Method

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Processing of raw data
[M_r: CH_3CH_2OH, 46]

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[6]

(e) Prepare a single table to show, for each alcohol, all of the measurements obtained directly from the experiment and the information processed from these data.
Your table should show the correct units for each of the headed columns.

[2]

(f) The apparatus shown in the diagram on page 2 and used in the experiment you have described is inefficient as much of the energy released from the burning alcohol is lost to the atmosphere.
You are to plan **two simple changes** to the apparatus shown on page 2 that will reduce the loss of heat energy to the atmosphere.
Draw a diagram of your improved apparatus, indicating and explaining how these changes will reduce the loss of heat energy.

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improvement 1 .....

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improvement 2 .....

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[2]

[Total: 15]

2 Basic copper(II) carbonate is a mixture of copper(II) carbonate and copper(II) hydroxide with varying amounts of water of crystallisation.
The formula may be represented as $CuCO_3.Cu(OH)_2.\boldsymbol{x}H_2O$.

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A group of students conduct an experiment to determine the relative formula mass and the actual value of $\boldsymbol{x}$ in the formula of the basic copper(II) carbonate, $CuCO_3.Cu(OH)_2.\boldsymbol{x}H_2O$.

This basic carbonate decomposes on heating.

$$CuCO_3.Cu(OH)_2.\boldsymbol{x}H_2O(s) \longrightarrow 2CuO(s) + CO_2(g) + (\boldsymbol{x}+1)H_2O(g)$$

Each student is provided with a sample of the solid basic carbonate and the following apparatus.

- a boiling-tube
- a test-tube holder
- a chemical balance, reading to 2 decimal places
- a Bunsen burner

Method

- The empty boiling-tube is weighed.
- The sample of basic copper(II) carbonate is tipped into the boiling-tube which is reweighed.
- The carbonate is heated, gently at first, as carbon dioxide and water vapour are given off. The carbonate is then heated strongly.
- Heating is continued until all of the green colour of the initial solid has turned to the black colour of copper(II) oxide.
- The apparatus is cooled and the mass of the tube and residue is measured.

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The results of the experiment are recorded below.

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	A	B	C	D	E	F
student	mass of empty boiling-tube /g	mass of boiling-tube and basic carbonate before heating /g	mass of boiling-tube and residue after heating /g			
1	10.32	11.19	10.92			
2	10.05	11.56	11.09			
3	10.11	12.33	11.24			
4	9.94	12.39	11.62			
5	9.99	13.73	12.56			
6	10.23	14.68	13.28			
7	10.01	15.19	13.56			
8	9.87	15.80	13.97			
9	9.96	16.62	14.66			
10	9.84	17.83	15.46			

(a) Use the additional columns of the table to record the calculated values that will enable you to determine the relative formula mass, M_r, of basic copper(II) carbonate and the value of ***x*** in $CuCO_3.Cu(OH)_2.\boldsymbol{x}H_2O$.

You may use some or all of the columns. Label the columns you use, including the units and an equation to show how the value is calculated. You may use the column headings **A** to **F** in the equations e.g. **C** – **B**.

Make certain that your processed values show the precision of the apparatus used. [2]

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(b) Present the values calculated in **(a)** in graphical form. Draw the line of best-fit.

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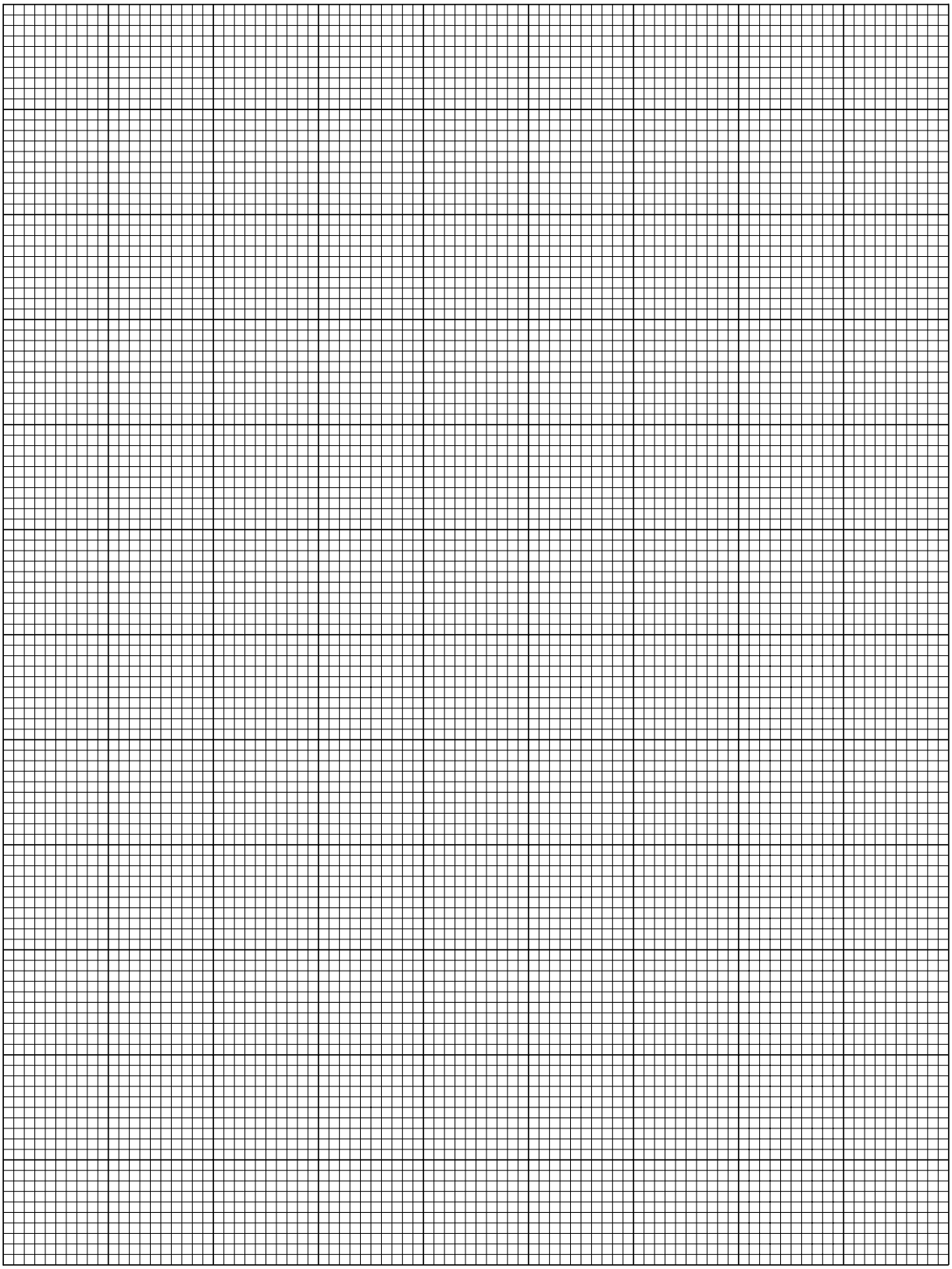

[4]

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(c) Give the co-ordinates of the **most significant** anomalous point.
By reference to the instructions for the experiment suggest an explanation for this anomaly.

co-ordinates .....

explanation .....

.....

.....[2]

(d) The students note that points plotted when using higher masses of the basic carbonate lie to one side of the line of best-fit.

Suggest an explanation for this observation.

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.....[1]

(e) How would you modify the experiment to overcome the problem described in **(d)**?

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.....[1]

(f) Draw construction lines on the graph to derive values to enable you to calculate the relative formula mass of the basic copper(II) carbonate and the value of ***x*** in $CuCO_3.Cu(OH)_2.\boldsymbol{x}H_2O$**.**

Values read from graph, including units

x-axis ..... y-axis .....

Calculation of the relative formula mass, M_r
[A_r: H, 1.0; C, 12.0; O, 16.0; Cu, 63.5]

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(f) ***continued***

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Calculation of ***x*** in the formula

[2]

(g) By considering the data you have processed and the graph you have drawn, explain if the experimental procedure described is suitable for the determination of the relative formula mass of the basic carbonate.

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.....[1]

(h) What other measurements could be made during the course of the experiment to provide alternative data to determine the relative formula mass and the value of ***x***?

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.....[1]

(i) Explain why the precision of the experiment would improve if students used a chemical balance weighing to 3 decimal places.

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.....[1]

[Total: 15]

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