Cambridge International Examinations
Cambridge International Advanced Subsidiary and Advanced Level

CANDIDATE NAME

CENTRE NUMBER

CANDIDATE NUMBER

4379664099

CHEMISTRY **9701/52**

Paper 5 Planning, Analysis and Evaluation **May/June 2016**

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 an HB pencil for any diagrams or graphs.
Do not use staples, paper clips, glue or correction fluid.
DO **NOT** WRITE IN ANY BARCODES.

Answer **all** questions.
Electronic calculators may be used.
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.

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

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1 A more reactive metal will displace a less reactive metal from a solution of its salt. This reaction is exothermic. If the same reaction is set up in an electrochemical cell then, instead of an enthalpy change, electrical energy is produced and a cell voltage can be measured.

You are to plan an investigation of the reaction of three different metals (magnesium, iron and zinc) with aqueous copper(II) sulfate. You will plan to investigate whether there is a relationship between their cell potential values, $E^{\ominus}_{cell}$, and their enthalpy changes of reaction, ΔH_r.

$$Mg(s) + Cu^{2+}(aq) \rightarrow Mg^{2+}(aq) + Cu(s)$$
$$Fe(s) + Cu^{2+}(aq) \rightarrow Fe^{2+}(aq) + Cu(s)$$
$$Zn(s) + Cu^{2+}(aq) \rightarrow Zn^{2+}(aq) + Cu(s)$$

Copper(II) sulfate solution is classified as a **moderate hazard**.
Zinc sulfate solution is classified as **corrosive**.
Iron(II) sulfate solution is classified as a **health hazard**.

(a) Predict how ΔH_r may change as $E^{\ominus}_{cell}$ increases. Give a reason for your prediction.

....

....

.... [1]

(b) The first part of the investigation is to determine the enthalpy change, ΔH_r, for the reaction of the same number of moles of three powdered metals with 0.500 mol dm^{-3} copper(II) sulfate.

When determining the ΔH_r for the reaction of the metals listed above with aqueous copper(II) sulfate,

the independent variable is, ...

....

the dependent variable is. ....

....
[2]

You are provided with a sample of powdered metal and 50.0 cm^3 of 0.500 mol dm^{-3} aqueous copper(II) sulfate.

(c) **(i)** Draw a fully labelled diagram to show how the apparatus should be set up to allow you to determine the increase in temperature of aqueous copper(II) sulfate.
You should use apparatus normally found in a school or college laboratory.

[1]

(ii) State the measurements you would make in your experiment.

....

....

.... [2]

(iii) Other than eye protection, state **one** precaution you would take to make sure that the experiment proceeds safely.

....

.... [1]

(iv) For the reaction with magnesium, calculate the mass of magnesium, in g, you would use so that it is in a small excess. You must show your working.
[A_r: Mg, 24.3]

mass of Mg = ... g [2]

(v) Explain why the metal used should be in powdered form rather than in strips.

....

.... [1]

(vi) The aqueous copper(II) sulfate and metal mixture should be stirred continuously.
Explain why.

....

.... [1]

(d) In one experiment, the increase in temperature when excess magnesium powder is added to 50.0 cm^3 of 0.500 mol dm^{-3} aqueous copper(II) sulfate is 58.5 °C.

Calculate the enthalpy change for this reaction, ΔH_r, in kJ mol^{-1}.
Assume the specific heat capacity, c, of the reaction mixture is 4.18 J g^{-1} K^{-1}.
Assume 1.0 cm^3 of 0.500 mol dm^{-3} aqueous copper(II) sulfate has a mass of 1.0 g.
Include a sign in your answer.

$$Mg(s) + Cu^{2+}(aq) \rightarrow Mg^{2+}(aq) + Cu(s)$$

ΔH_r = ... kJ mol^{-1} [2]

(e) The second part of the investigation involves determining the cell potential, $E^{\ominus}_{cell}$, for the three electrochemical cells.

cell reaction
$Mg(s) + Cu^{2+}(aq) \rightarrow Mg^{2+}(aq) + Cu(s)$
$Zn(s) + Cu^{2+}(aq) \rightarrow Zn^{2+}(aq) + Cu(s)$
$Fe(s) + Cu^{2+}(aq) \rightarrow Fe^{2+}(aq) + Cu(s)$

Draw a diagram of the apparatus you would use to measure the $E^{\ominus}_{cell}$ for the magnesium/copper cell. Your labels should include the **names** of the metals and the **names** and **concentrations** of the solutions you would use.

[3]

(f) Explain why the enthalpy change determination and cell potential determination should be carried out at the same temperature as each other.

....

....

.... [1]

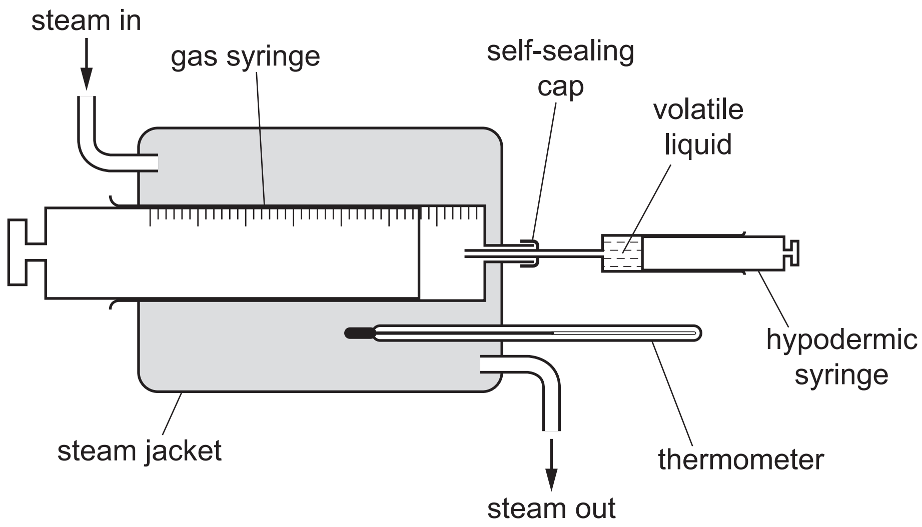
(g) Accepted $E^{\ominus}_{cell}$ values are shown for the cell reactions.

	cell reaction	$E^{\ominus}_{cell}$/V	ΔH_r
1	$Mg(s) + Cu^{2+}(aq) \rightarrow Mg^{2+}(aq) + Cu(s)$	+2.72	
2	$Zn(s) + Cu^{2+}(aq) \rightarrow Zn^{2+}(aq) + Cu(s)$	+1.10	
3	$Fe(s) + Cu^{2+}(aq) \rightarrow Fe^{2+}(aq) + Cu(s)$	+0.78	

Use your prediction in **(a)**, your answer to **(d)** and data from the table to predict ΔH_r values for reactions 2 and 3.
Complete the table with these values. [1]

[Total: 18]

2 The relative molecular mass, M_r, of volatile liquids can be determined using the apparatus below.



A known mass of volatile liquid is injected into the gas syringe using a hypodermic syringe. The injected volatile liquid vaporises and the volume of vapour is recorded.

The experiment can be repeated using different samples of the same volatile liquid. The following mathematical relationship can be used to calculate the relative molecular mass if the experiment is carried out at 100 °C and 1.01×10^5 Pa.

$$V = \left(\frac{3.07 \times 10^4}{M_r}\right) \times m$$

m is the mass of the volatile liquid in g.
V is the volume of the volatile liquid in cm^3 when vaporised.

A graph of V against m can be plotted.

A group of students is given a volatile liquid hydrocarbon, **Y**, and asked to find its relative molecular mass in a series of experiments using this procedure.

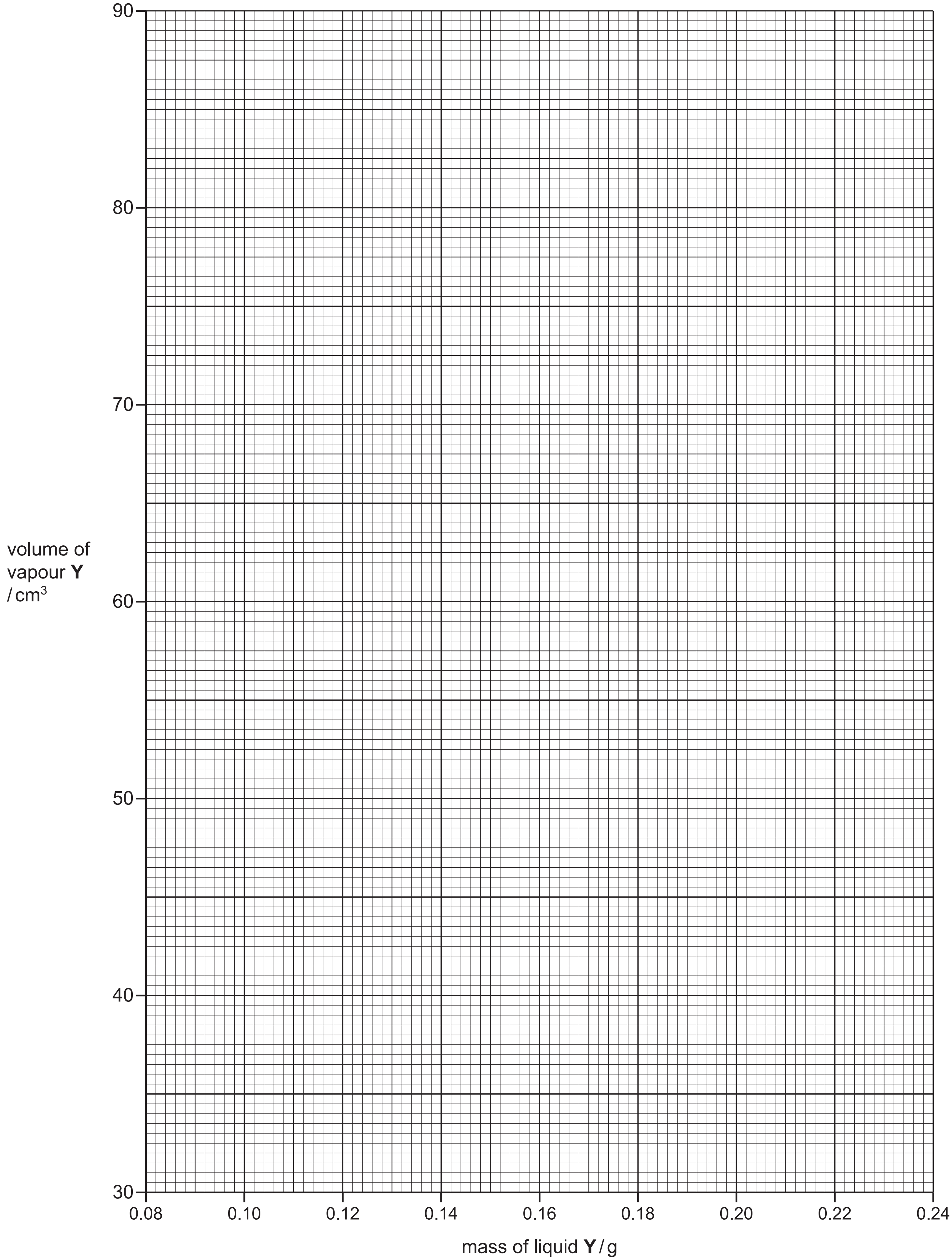
- A 100 cm^3 gas syringe is placed in a steam jacket.
- Approximately 5 cm^3 of air is pulled into the gas syringe.
- The temperature is allowed to reach a constant 100 °C.
- Once the air in the gas syringe has stopped expanding, its volume is recorded.
- The hypodermic syringe is filled with liquid **Y**.
- The total mass of the hypodermic syringe and liquid **Y** is recorded.
- A little liquid **Y** is injected into the hot gas syringe.
- The total mass of the hypodermic syringe is recorded again.
- The maximum volume of air and vapour in the gas syringe is recorded.
- The mass of liquid **Y** injected into the gas syringe is calculated and recorded.

The results from the group of students are given in the table.

mass of syringe + liquid **Y** before injection / g	mass of syringe + liquid **Y** after injection / g	volume of air in gas syringe before injection / cm^3	volume of air + vapour **Y** in gas syringe after injection / cm^3	mass of liquid **Y** used / g	volume of vapour **Y** / cm^3
4.83	4.68	7	55		
5.33	5.23	9	44		
4.85	4.64	13	85		
5.09	4.92	11	69		
5.31	5.07	14	97		
5.57	5.48	8	39		
5.32	5.12	9	79		
5.17	4.94	12	91		
4.84	4.72	7	48		
5.05	4.83	11	84		

(a) Process the results in the table to calculate both the masses of volatile liquid **Y** used and the volumes of vaporised **Y**. [2]

(b) Plot a graph on the grid on page 9 to show the relationship between mass of liquid **Y** and volume of vapour **Y**.
Use a cross (**×**) to plot each data point.
Draw the line of best fit. [2]


volume of vapour **Y** / cm³
90
80
70
60
50
40
30
0.08
0.10
0.12
0.14
0.16
0.18
0.20
0.22
0.24
mass of liquid **Y** / g

(c) Liquid **Y** evaporates easily, even at room temperature. This can cause anomalous results giving points below the line of best fit.

(i) Explain how such anomalies occur.

....

.... [1]

(ii) With reference to the experimental procedure, explain how this source of error could be minimised.

....

....

.... [1]

(d) **(i)** Determine the gradient of your graph. State the co-ordinates of both points you used for your calculation. Record the value of the gradient to **three** significant figures.

co-ordinates 1 ....

co-ordinates 2 ....

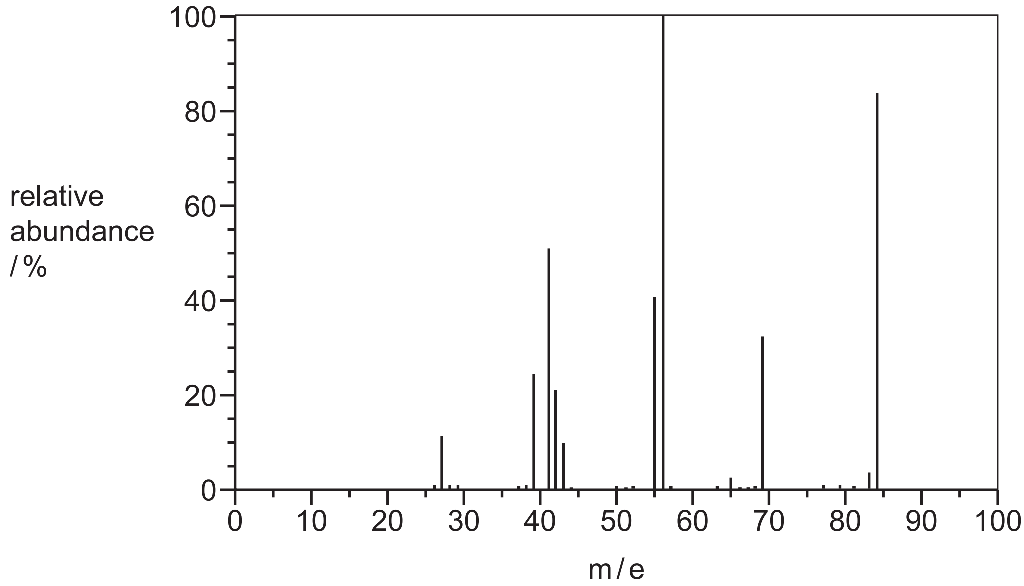
gradient = ... [2]

(ii) Use the gradient value in **(i)** and the mathematical relationship on page 7 to calculate the experimentally determined relative molecular mass of **Y**.

experimentally determined M_r of **Y** = ... [2]

(e) Compound **Y** is a hydrocarbon that contains 85.7% carbon by mass.

The diagram shows the mass spectrum of compound **Y**.



Use all the information given to determine the molecular formula of **Y**.

molecular formula of **Y** .... [2]

[Total: 12]

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