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

CANDIDATE NAME	

CENTRE NUMBER						CANDIDATE NUMBER					

3734662593

CHEMISTRY **9701/52**

Paper 5 Planning, Analysis and Evaluation **October/November 2009**

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 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.

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1	
2	
3	
Total	

This document consists of **10** printed pages and **2** blank pages.

DC (AT/KN) 11586/2

UNIVERSITY *of* CAMBRIDGE
International Examinations

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1 A group of students use a number of different acids to investigate how the enthalpy change of neutralisation, $\Delta H_{neutralisation}$, varies when the acids are neutralised with aqueous sodium hydroxide, NaOH.

You may use the following information in answering the question.

> The enthalpy change of neutralisation is the enthalpy change when 1 mol of water, H_2O, is formed in the neutralisation of an acid and base.
>
> $$H^+(aq) + OH^-(aq) \longrightarrow H_2O(aq)$$
>
> Strong acids are 100% dissociated into ions in solution.
> Weak acids are **not** 100% dissociated into ions in solution.
>
> Breaking of bonds is an endothermic process.
> Formation of bonds is an exothermic process.

(a) Hydrochloric acid, nitric acid and sulfuric acid are all strong acids.
Predict how $\Delta H_{neutralisation}$ values for these acids would compare with each other.

....

Predict and explain how the expected $\Delta H_{neutralisation}$ for a weak acid, such as ethanoic acid or ethanedioic acid, compares with that obtained for hydrochloric acid.

....

....

.... [2]

(b) In a series of experiments to determine the enthalpy change of neutralisation for each acid with 2.0 mol dm^{-3} sodium hydroxide, NaOH, the following aqueous acids are available.

hydrochloric acid,	HCl
sulfuric acid,	H_2SO_4
nitric acid,	HNO_3
ethanoic acid	CH_3CO_2H

Ethanedioic acid, $(CO_2H)_2.2H_2O$, is also available as a hydrated crystalline solid.

When determining the enthalpy change of neutralisation using the acids listed above in reaction with sodium hydroxide,

the independent variable is, ...

the dependent variable is. ....
[2]

(c) Draw and label a diagram of the apparatus you would use to determine the temperature change, ΔT, when each of the acids reacts with $30.0\,cm^3$ of $2.0\,mol\,dm^{-3}$ sodium hydroxide. Any experimental method that is normally carried out in a school or college laboratory may be described.

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Identify three aspects of the experimental method or its use that must be kept the same to ensure comparable results.
At least one of these should minimise heat loss from the apparatus.

1. ....

....

2. ....

....

3. ....

....

[2]

(d) In each experiment $30.0\,cm^3$ of $2.0\,mol\,dm^{-3}$ NaOH is to be used.
There is to be an excess of sodium hydroxide, NaOH.

Suggest appropriate volumes and concentrations for each of the acids to be used in the individual experiments.
In order that the experiments are equivalent, the total **final volumes** should be the same in each experiment.

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acid		volume/ cm^3	concentration /$mol\,dm^{-3}$
hydrochloric	HCl		
sulfuric	H_2SO_4		
nitric	HNO_3		
ethanoic	CH_3CO_2H		
ethanedioic	$(CO_2H)_2$		

[3]

(e) Ethanedioic acid is a hydrated crystalline solid, $(CO_2H)_2.2H_2O$.

Outline, step by step, how you would prepare, in a graduated flask, $250\,cm^3$ of a solution of ethanedioic acid with **exactly** the concentration you have given in the table above.
[A_r: C, 12.0; H, 1.0; O, 16.0]

....

....

....

....

....

....

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....

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....

....

....[4]

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(f) Show the mathematical expression for the enthalpy change of neutralisation of sodium hydroxide with hydrochloric acid, using the volume and concentration from **(d)** and 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]

(g) Hydrochloric acid is labelled **harmful** as it is an irritant.
Aqueous sodium hydroxide is labelled **corrosive**.

Suggest a suitable precaution that should be taken when carrying out the experiment using these two solutions.

....

....

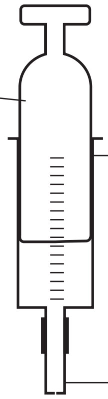
....[1]

[Total: 15]

2 If you have a container of gas with a tiny hole in the container, the gas will gradually escape through the hole. This is called **effusion**.

The rate at which a gas **effuses** (escapes) is related to the relative molecular mass, M_r, of that gas. The time taken for a measured volume of gas to escape is called the **effusion time**.

A student investigates the **effusion time** for a number of **dry gases** using the following apparatus.



The instructions given to the student for the experiment are as follows.

- Attach two markers to the scale on the gas syringe, 70 cm^3 apart.
- Completely fill the syringe with the dry gas under investigation.
- Use the piston on the syringe to push all of the gas out of the syringe.
- Completely fill the syringe with the dry gas a second time.
- Clamp the syringe in an upright position, keeping hold of the piston of the syringe.
- Release the piston – as it descends gas **effuses** from the small hole at the end of the effusion tube.
- Record the time taken for the piston to travel between the two marks.
- Repeat the experiment a number of times for each gas under investigation.

  Mean times, to the nearest second, obtained by the student are given in the table below.

		M_r	**effusion time/s**	$(M_r)^2$	$\sqrt{M_r}$
hydrogen	H_2	2	19		
oxygen	O_2	32	76		
carbon dioxide	CO_2	44	89		
butane	C_4H_{10}	58	102		
chlorine	Cl_2	71	113		

(a) Complete the table above.

Calculate $(M_r)^2$ to 3 significant figures.

Calculate $\sqrt{M_r}$ to 4 significant figures. [1]

(b) Plot the following graphs using data from the table.

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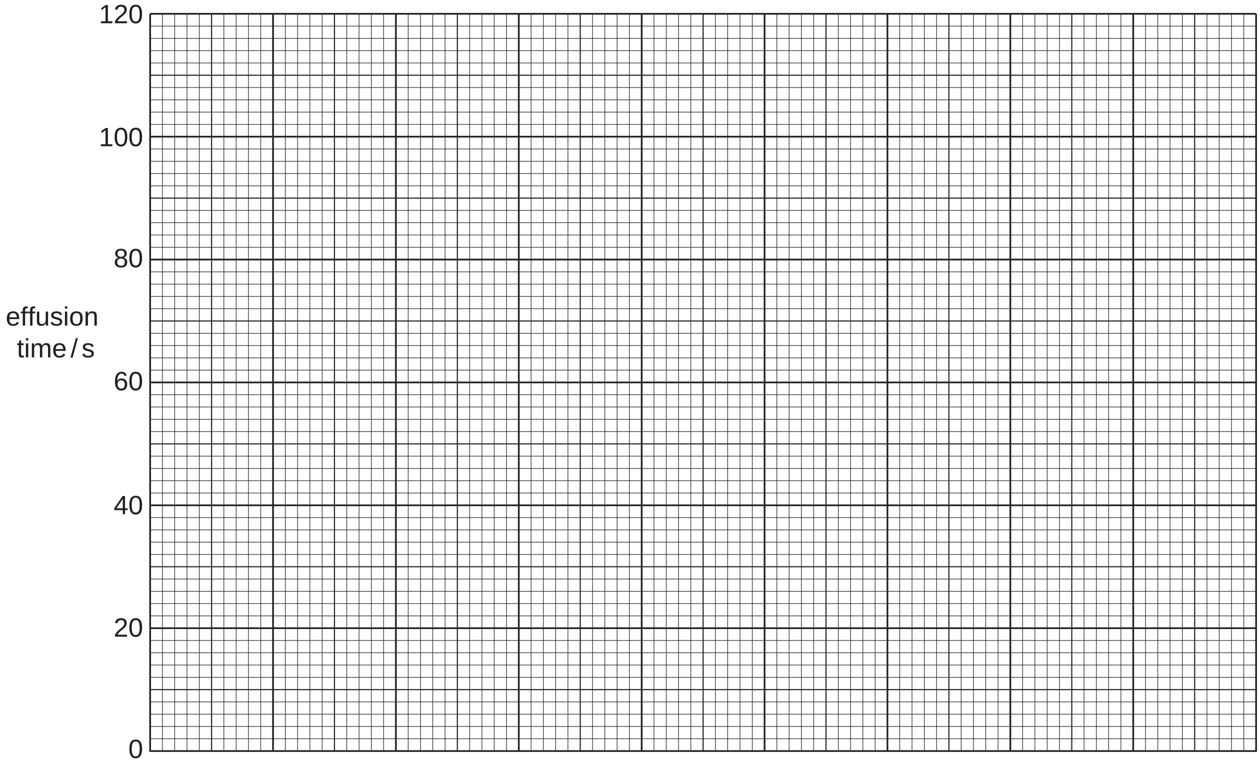
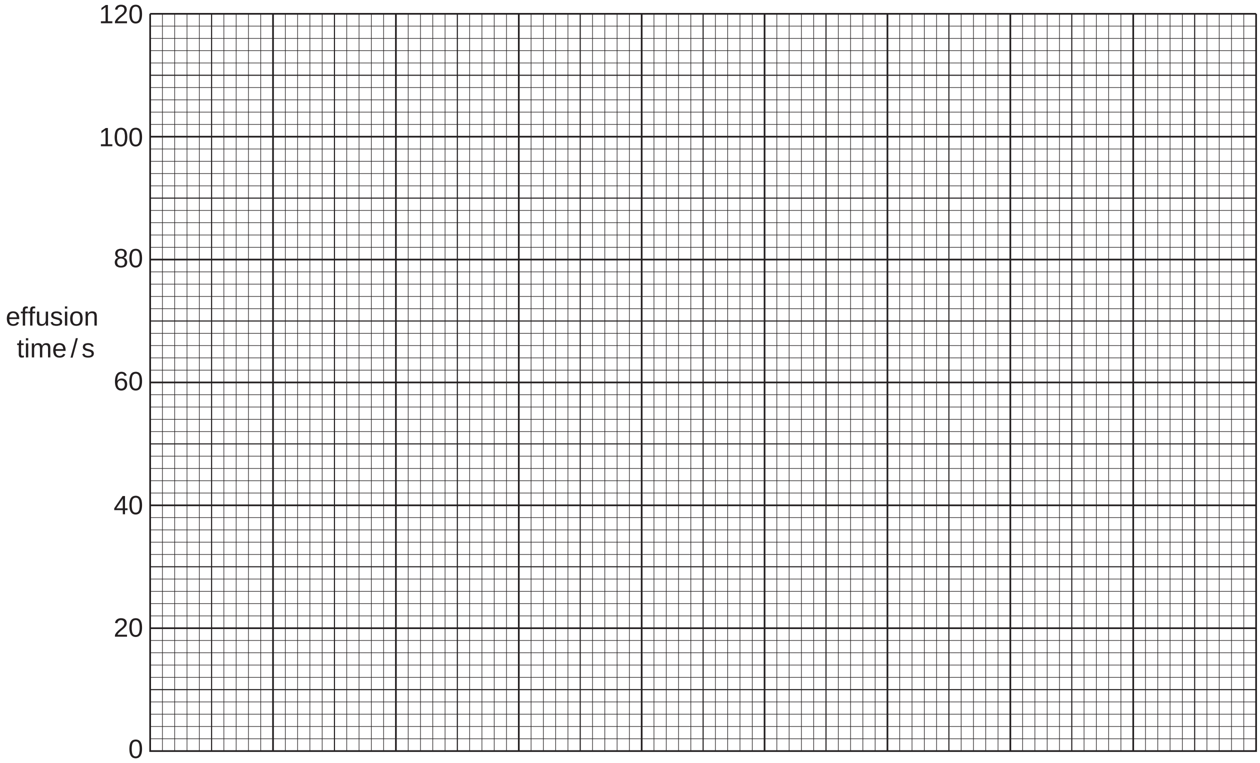
(i) Effusion time against relative molecular mass, M_r.



(ii) Effusion time against the square of the relative molecular mass, $(M_r)^2$.



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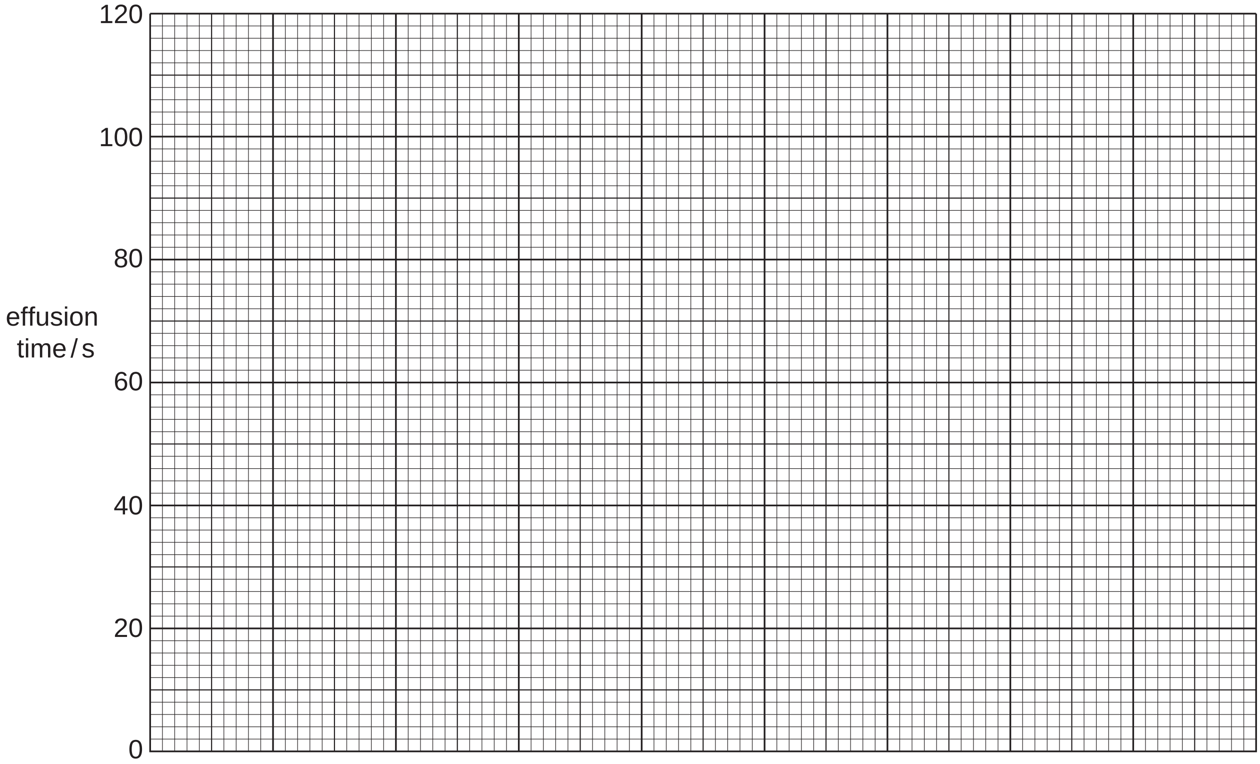
(iii) Effusion time against the square root of the relative molecular mass, $\sqrt{M_r}$.



[3]

(c) From the graphs drawn, deduce and explain the relationship between effusion time and the relative molecular mass of the gas.
Credit will be given for stating the relationship in mathematical terms.

....

....

.... [2]

(d) Suggest a reason for using **dry gas** in each of the experiments.

....

.... [1]

(e) State and explain the effect on the effusion time of filling the syringe with hydrogen from a flask in which zinc is reacting with dilute hydrochloric acid.

....

....

[1]

[Total: 8]

3 A group of students reduce samples of copper oxide by passing hydrogen gas over a weighed sample of the oxide contained in a porcelain boat.

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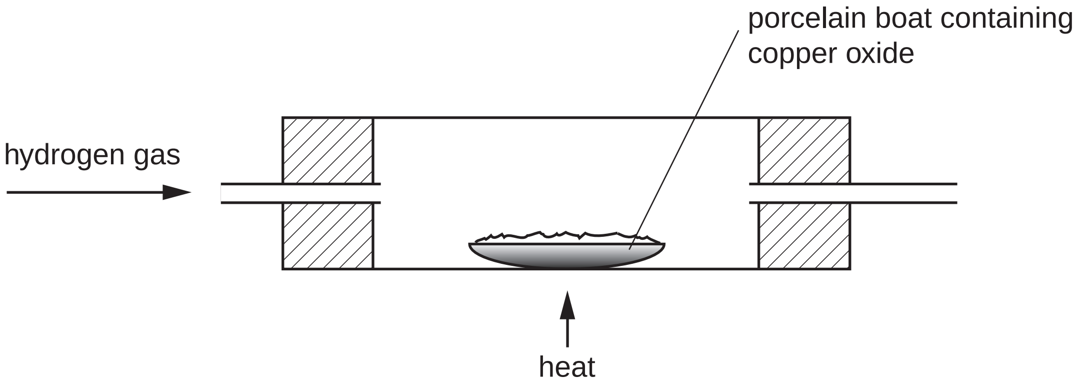

The results of the experiment are given below.

student	mass of porcelain boat / g	mass of boat + copper oxide / g	mass of boat + copper after heating / g			
1	5.55	7.71	7.11			
2	5.18	8.07	7.49			
3	5.17	10.05	9.07			
4	5.39	10.91	10.06			
5	5.46	11.64	10.40			
6	4.99	12.02	10.61			

(a) Complete the table above to find, for each sample of the oxide,

(i) the mass of copper,

(ii) the mass of oxygen,

(iii) the mass of copper combined with **1.00 g** of oxygen.

[2]

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(b) Give the number of any student whose results you consider to be anomalous.
By making reference to the experimental method for reducing the copper oxide, explain a possible cause for this anomaly.

....

....

....

....

....

.... [1]

(c) From the results in **(a)(iii)**, calculate an appropriate mean for the mass of copper combined with 1.00 g of oxygen.
Show all your working, indicating clearly the results used in determining this mean value.

The mean mass of copper, combined with 1.00 g of oxygen is............................... g [2]

(d) Use your answer to **(c)** to determine the formula of the copper oxide. Show all your working.
[A_r: O, 16.0; Cu, 63.5]

The formula of the copper oxide is .... [2]

[Total: 7]

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