Cambridge International A Level

**Cambridge International Examinations**
Cambridge International Advanced Level

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|---|---|
| CANDIDATE NAME | |
| CENTRE NUMBER | |
| CANDIDATE NUMBER | |

*2125427507*

**CHEMISTRY** **9701/51**

Paper 5 Planning, Analysis and Evaluation **October/November 2014**

**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 **10** printed pages and **2** blank pages.


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**1** A solder is an alloy of metals which is used to join other metal pieces together.
A specialist solder that can be used to join together pieces of aluminium is made from a mixture by mass of 65% zinc, 20% aluminium and 15% copper.

You are to plan an experimental procedure to confirm the composition of a powdered sample of this solder, by adding reagents and then extracting from the mixture each of the following in sequence;

(i) the copper metal,
(ii) the aluminium as aluminium hydroxide,
(iii) the zinc as zinc hydroxide.

You are provided with

- a sample of this solder, with approximate mass 4 g,
- 1.00 mol $dm^{-3}$ sulfuric acid,
- 1.00 mol $dm^{-3}$ ammonia.

No other reagents should be used. Standard laboratory equipment is available including a balance, accurate to two decimal places.

**(a)** Complete the flowchart below to show the order in which the reagents would be added to the solder to allow you to extract and separate the components as copper metal, **(Step 1)**, aluminium hydroxide, **(Step 2)**, and zinc hydroxide, **(Step 3)**.
You are reminded that aqueous ammonia contains both the base $OH^-$ and the complex-forming molecule $NH_3$.

solder →

| Step 1 | Step 2 | Step 3 |
|---|---|---|
| reagent(s) added | reagent(s) added | reagent(s) added |
| ..... | ..... | ..... |
| ..... | ..... | ..... |
| substance(s) present at the end of the reaction | substance(s) present at the end of the reaction | substance(s) present at the end of the reaction |
| ..... | ..... | ..... |
| ..... | ..... | ..... |
| ..... | ..... | ..... |
| substance(s) removed by filtration (if any) | substance(s) removed by filtration (if any) | substance(s) removed by filtration (if any) |
| ..... | ..... | ..... |
| ..... | ..... | ..... |

[5]

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**(b)** For some of the steps in the procedure you would need to be careful to add an appropriate quantity of a reagent.
For each step of your procedure explain why particular quantities of reagent should be chosen.

**Step 1** .....

.....

.....

**Step 2** .....

.....

.....

**Step 3** .....

.....

..... [4]

**(c)** The aluminium hydroxide and zinc hydroxide that have been extracted are difficult to dry so it is better to convert them to their oxides.
Describe how this could be done and how you would make sure that each hydroxide had been completely converted into its oxide.

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..... [2]

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**[Turn over**

**(d)** The purpose of the experiment is to confirm the composition of the solder.
When the experiment is carried out state

- the measurements that would be taken,
- what you would do to the copper to make sure that the correct value is obtained.

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.....

..... [2]

**(e)** If the mass of aluminium oxide obtained was 1.50 g, calculate the mass of aluminium that was present in the solder.
($A_r$: A*l*, 27.0; O, 16.0)

[1]

**(f)** Even if the experimental difficulties of extracting all of the copper from the mixture were overcome, it would be difficult to obtain an accurate mass of copper from this experiment.
Suggest why.

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.....

.....

..... [1]

[Total: 15]

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**QUESTION 2 STARTS ON THE NEXT PAGE.**

**2** The acid dissociation constant, $K_a$, of a weak monoprotic acid, **HA**, is to be determined from the measurement of the pH change that occurs when it is titrated with an aqueous solution of sodium hydroxide.

2.70 g of **HA** was dissolved in distilled water to make exactly 250.0 $cm^3$ of solution.
25.00 $cm^3$ of the solution was pipetted into a beaker.
The pH of the acid in the beaker was measured and recorded in the table below.

A burette was then filled with aqueous sodium hydroxide and the 25.00 $cm^3$ of **HA** was titrated by adding volumes of the aqueous sodium hydroxide to the beaker as indicated in the table below. After each addition the pH was measured and the value recorded.

| volume of sodium hydroxide added / $cm^3$ | pH measured |
|---|---|
| 0.00 | 2.41 |
| 2.00 | 2.75 |
| 4.00 | 3.09 |
| 8.00 | 3.46 |
| 12.00 | 3.52 |
| 16.00 | 3.96 |
| 20.00 | 4.20 |
| 24.00 | 4.50 |
| 28.00 | 5.05 |
| 30.00 | 7.00 |
| 32.00 | 11.55 |
| 36.00 | 12.00 |

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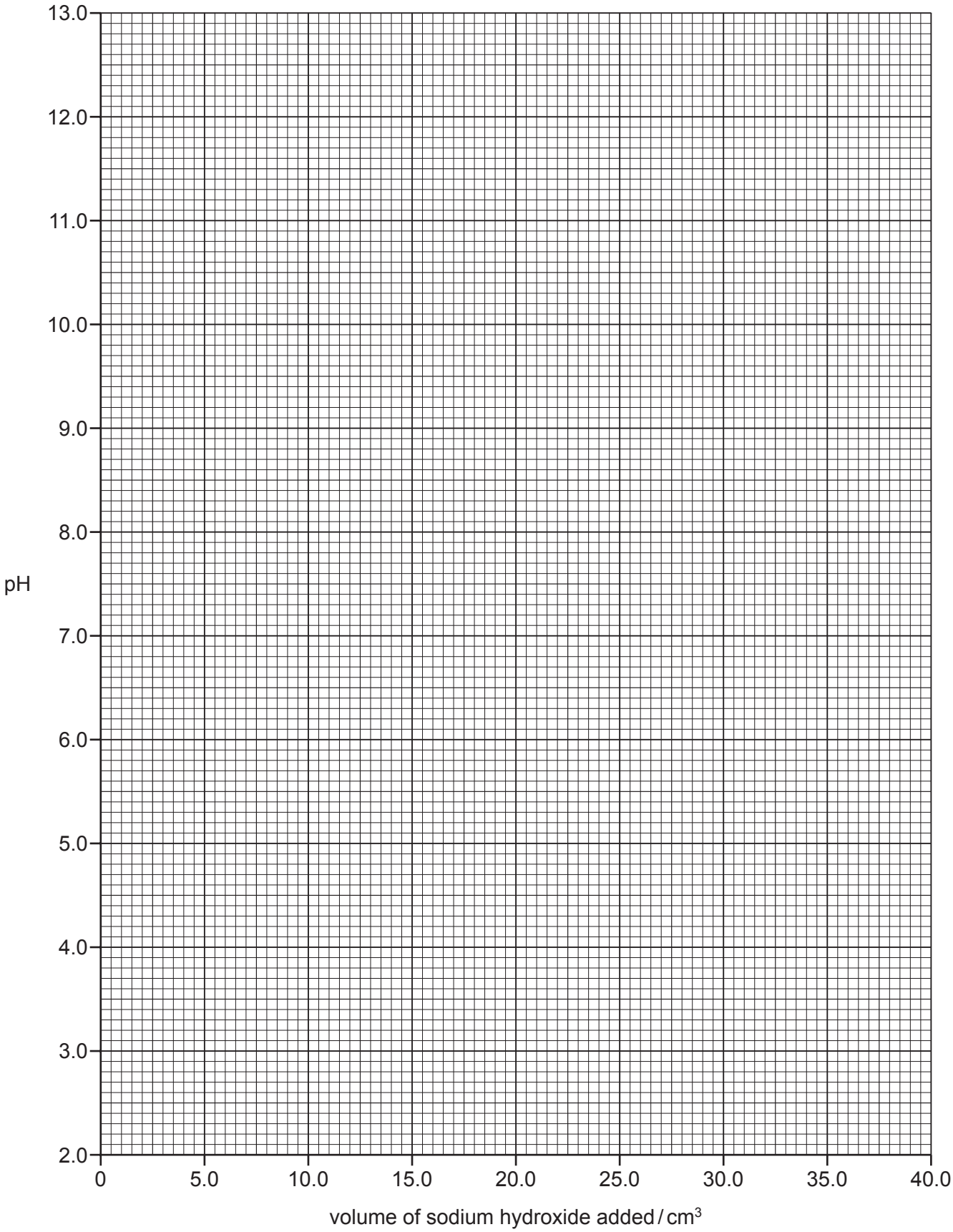
**(a)** Plot a graph to show how the pH of the mixture changes with the volume of added aqueous sodium hydroxide as shown in the table.
Draw a smooth curve, using the plotted points on your graph, to produce a titration curve for the addition of aqueous sodium hydroxide to the acid **HA**.




[2]

**(b)** Circle any points on the graph that are anomalous and suggest a reason why this might occur.

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.....

..... [2]

**(c)** What would be a suitable range of pH values in which an indicator would change colour to identify the end point of this neutralisation?

.....

..... [1]

**(d)** 30.00 $cm^3$ of aqueous sodium hydroxide is required to neutralise 25.00 $cm^3$ of **HA** and the equation for the neutralisation is shown.

$$NaOH + HA \rightarrow NaA + H_2O$$

**(i)** Excluding water, state the three ions or molecules that will be present in the highest concentration when 15.00 $cm^3$ of aqueous sodium hydroxide has been added to 25.00 $cm^3$ of **HA**.

.....

..... [1]

**(ii)** State and explain how the concentrations of these ions or molecules compare.

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..... [2]

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**(e)** Use your graph to determine the pH obtained when 15.00 $cm^3$ of aqueous sodium hydroxide is added to 25.00 $cm^3$ of **HA**. Use this pH to determine the value of $K_a$ for **HA**.

[3]

**(f)** **(i)** Use your answer to **(e)** and the initial pH of **HA** from the table to calculate the concentration of **HA** in mol $dm^{-3}$.

[2]

**(ii)** Calculate the initial concentration of **HA**, in g $dm^{-3}$, and use this together with your answer to **(f)(i)** to calculate the relative molecular mass, $M_r$, of **HA**.
(Remember that 2.70 g of **HA** was dissolved in distilled water to make exactly 250.0 $cm^3$ of solution.)

[1]

**(g)** Even if the experiment is done very carefully with very accurate apparatus, the answer obtained for the molecular mass of **HA** is likely to be subject to error. Suggest why.

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..... [1]

[Total: 15]

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