Cambridge Assessment International Education

Cambridge International AS & A Level

CANDIDATE NAME	

CENTRE NUMBER		CANDIDATE NUMBER	

0882547400

CHEMISTRY **9701/52**

Paper 5 Planning, Analysis and Evaluation **February/March 2020**

1 hour 15 minutes

You must answer on the question paper.

No additional materials are needed.

INSTRUCTIONS
- Answer **all** questions.
- Use a black or dark blue pen. You may use an HB pencil for any diagrams or graphs.
- Write your name, centre number and candidate number in the boxes at the top of the page.
- Write your answer to each question in the space provided.
- Do **not** use an erasable pen or correction fluid.
- Do **not** write on any bar codes.
- You may use a calculator.
- You should show all your working, use appropriate units and use an appropriate number of significant figures.

INFORMATION
- The total mark for this paper is 30.
- The number of marks for each question or part question is shown in brackets [ ].

This document has **8** pages. Blank pages are indicated.

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1 Brass is an alloy of copper and zinc. Typical copper concentrations vary from 50% to 85%, depending upon the properties needed in the alloy. There may be small amounts of other metals present.

A student found a method to determine the percentage of copper in a sample of brass.

A known mass of brass powder is reacted with excess concentrated nitric acid. Both the copper and the zinc and any other metals present are oxidised into aqueous ions by the nitric acid. The amount of Cu^{2+}(aq) ions present can be determined by a titration technique.

step 1 Use a weighing boat to accurately weigh by difference approximately 2 g of brass powder and place the brass into a small glass beaker.

step 2 In a fume cupboard add **approximately** 20 cm^3 of concentrated nitric acid to the brass in the beaker. Allow the brass to completely react to form solution **A**.

The equation for the reaction is shown.

$$Cu(s) + 4HNO_3(aq) \rightarrow Cu(NO_3)_2(aq) + 2NO_2(g) + 2H_2O(l)$$

step 3 Dilute **all** of solution **A** to form exactly 250.0 cm^3 of solution **B**.

step 4 Place 25.00 cm^3 of solution **B** into a conical flask.

step 5 Use a dropping pipette to add aqueous sodium carbonate, Na_2CO_3(aq), to solution **B** in the conical flask until there is no more acid present.

step 6 Add approximately 20 cm^3 of aqueous potassium iodide, KI(aq), to the conical flask. A white precipitate forms as well as a brown solution of aqueous iodine, I_2(aq).

step 7 Fill a burette with 0.100 mol dm^{-3} sodium thiosulfate solution, $Na_2S_2O_3$(aq), so it is ready for the titration in **step 8**.

step 8 Carry out a titration of the aqueous iodine produced in the conical flask against the 0.100 mol dm^{-3} $Na_2S_2O_3$(aq).

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(a) Outline how the student should accurately weigh by difference in **step 1** in order that the exact mass of brass transferred into the small glass beaker is known. Include a results table, with appropriate headings, ready for the student to fill in.

....

....

[2]

(b) Suggest why it is necessary to do **step 2** in a fume cupboard.

.... [1]

(c) Outline how the student should carry out **step 3**. Include the name and capacity of the suitable piece of apparatus in which solution **B** should be prepared.

....

....

....

.... [2]

(d) Name the apparatus needed to transfer solution **B** into the conical flask in **step 4**.

.... [1]

(e) State how the student would know there was no more acid present in the mixture in **step 5**.

.... [1]

(f) The student is given 200 cm^3 of 0.100 mol dm^{-3} $Na_2S_2O_3(aq)$.

Outline how the student should use this solution to fill the burette in **step 7** so it is ready for titration. Include any relevant procedures the student should follow to ensure the burette is correctly filled before any readings are taken.

....

....

....

.... [2]

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(g) The titration table the student used is shown.

(i) Complete the table and calculate the mean titre to be used in calculating the percentage of copper in brass.
Show your working.

titration number	rough	1	2	3	
final burette reading / cm^3	20.50	40.25	19.90	39.65	
initial burette reading / cm^3	0.00	20.60	0.00	19.90	
titre / cm^3					

mean titre = ... cm^3 [2]

(ii) The burette used by the student has graduations of 0.10 cm^3.

Determine the percentage error in the titre measured in titration number 2.

Show your working.

percentage error = ... [1]

(iii) Other than a change in apparatus, suggest one change to the experiment which would lead to a reduction in the percentage error in a measured titre.

....

.... [1]

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(h) **Steps 1–8** were repeated, this time using 1.88 g of brass. The end-point of the titration was found to be 16.50 cm^3.

The equations for the reactions occurring are shown.

equation **1** (**step 6**) $2Cu^{2+}(aq) + 4I^-(aq) \rightarrow 2CuI(s) + I_2(aq)$

equation **2** (**step 8**) $I_2(aq) + 2S_2O_3^{2-}(aq) \rightarrow 2I^-(aq) + S_4O_6^{2-}(aq)$

(i) Determine the number of moles of I_2 formed when excess KI(aq) was added to 25.00 cm^3 of solution **B** in **step 6**.

Use the data from the repeated experiment in your calculations.

moles of I_2 = ... [2]

(ii) Use your answer to **(h)(i)** to determine the mass of Cu^{2+} ions in solution **A** and therefore the percentage by mass of copper in this sample of brass.
If you were unable to obtain an answer to **(h)(i)**, assume the number of moles of I_2 to be 8.85×10^{-4} mol. This is **not** the correct value.
[A_r: Cu, 63.5]

percentage by mass of copper in the sample of brass = ... [3]

(i) A small percentage of silver is sometimes found in some brass alloys.

In **step 2**, when concentrated nitric acid is added, silver metal is oxidised to silver ions, $Ag^+(aq)$.

At the end of **step 6** the $Ag^+(aq)$ ions no longer remain in solution.

Explain why.

.... [1]

[Total: 19]

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2 The activation energy, E_a, of the reaction between aqueous manganate(VII) ions, $MnO_4^-(aq)$, and aqueous ethanedioate ions, $C_2O_4^{2-}(aq)$, can be determined as follows.

step 1 Use a pipette to transfer 10.00 cm^3 of 0.0200 mol dm^{-3} $MnO_4^-(aq)$ into a boiling tube.

step 2 Use a second pipette to transfer 10.00 cm^3 of 0.0500 mol dm^{-3} $C_2O_4^{2-}(aq)$ into a second boiling tube.

step 3 Place both boiling tubes into a water-bath at approximately 50 °C and allow the temperature of both solutions to become equal and constant.

step 4 Record this constant temperature.

step 5 Pour the $C_2O_4^{2-}(aq)$ solution into the boiling tube containing the $MnO_4^-(aq)$ solution and immediately start the timer. Continue to stir the mixture during the reaction.

step 6 When the reaction finishes, stop the timer and record the time.

step 7 Repeat the experiment at different temperatures and record the results.

The student used their recorded data to complete columns 1–3 of the table.

experiment number	average temperature of reaction mixture (T) / K	time (t) / s	$\frac{1}{T}$ / K^{-1}	log t
1	333	11		
2	323	35		
3	315	76		
4	310	145		
5	304	284		

(a) An extra procedural step in the method is required in order to be able to calculate the average temperature of the reaction mixture throughout each experiment.

State the extra procedural step that needs to be done.

.... [1]

(b) Complete the empty columns in the table, giving all values to **three significant figures**. [2]

(c) Suggest why an experiment with an average temperature of 70 °C (343 K) would produce a result that is less accurate than the other experiments.

.... [1]

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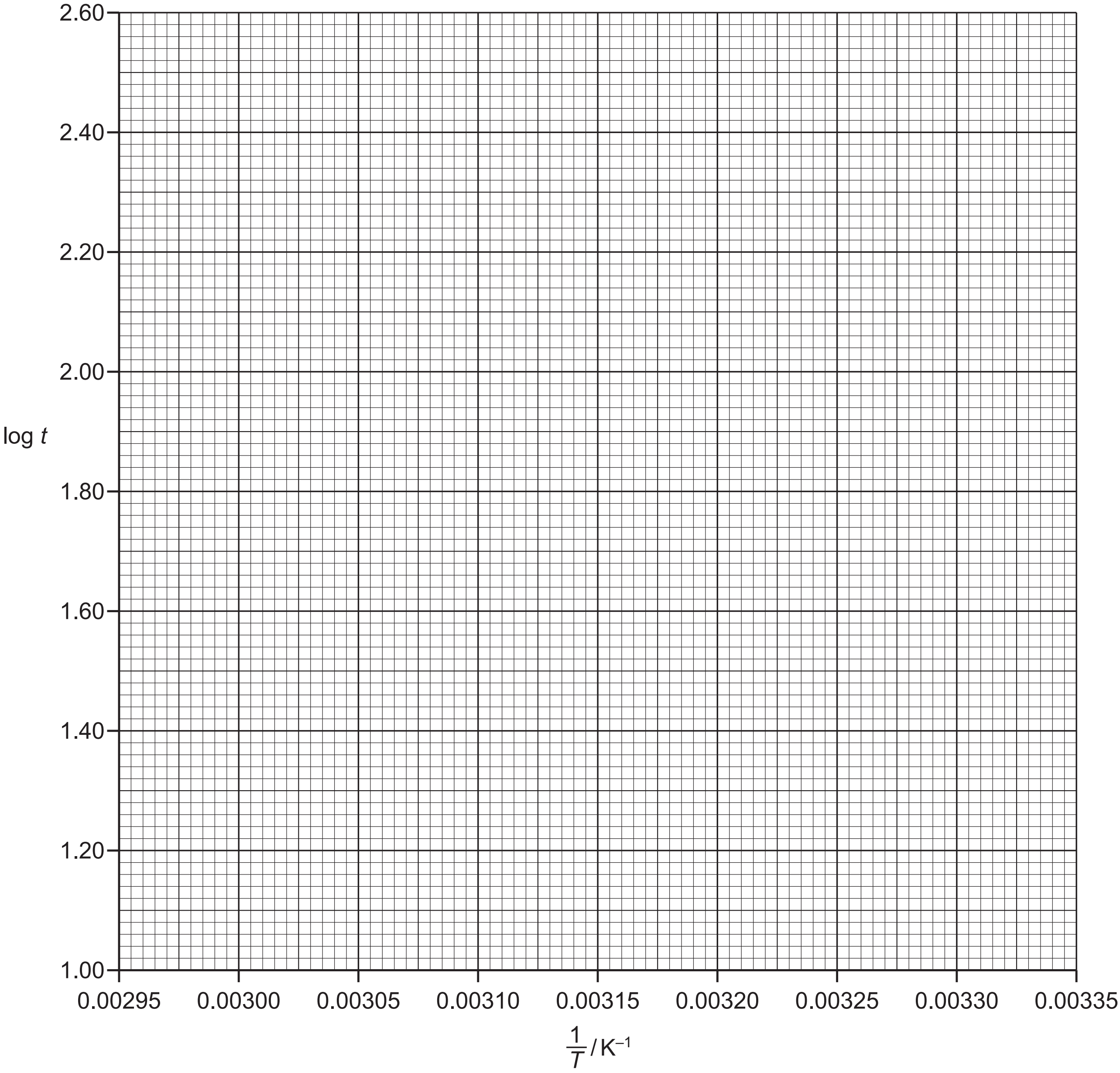
(d) Identify the dependent variable.

.... [1]

(e) Plot a graph on the grid to show the relationship between log t and $\frac{1}{T}$. Use a cross (×) to plot each data point. Draw a line of best fit.



[2]

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(f) The equation for the line of best fit is shown.

$$\log t = \frac{E_a}{2.303\,RT} + \text{constant}$$

$R = 8.314\,\text{J mol}^{-1}\,\text{K}^{-1}$

(i) Use your graph to determine the gradient of the line of best fit.

State the coordinates of both points you used in your calculation. These must be selected from your line of best fit.

Give the gradient to **three significant figures**.

coordinates 1 .... coordinates 2 ....

gradient = ... K
[2]

(ii) Determine the activation energy, E_a, of this reaction.

Give your answer to **three significant figures**. Include units.

E_a = ...

units = ...
[2]

[Total: 11]

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