Cambridge International Examinations
Cambridge International Advanced Subsidiary and Advanced Level

CANDIDATE NAME

CENTRE NUMBER

CANDIDATE NUMBER

1081142765

CHEMISTRY **9701/52**

Paper 5 Planning, Analysis and Evaluation **October/November 2017**

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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CAMBRIDGE International Examinations

1 Verdigris is a green pigment that contains both copper(II) carbonate, $CuCO_3$, and copper(II) hydroxide, $Cu(OH)_2$, in varying amounts.

Both copper compounds react with dilute hydrochloric acid.

$$CuCO_3(s) + 2HCl(aq) \rightarrow CuCl_2(aq) + CO_2(g) + H_2O(l)$$

$$Cu(OH)_2(s) + 2HCl(aq) \rightarrow CuCl_2(aq) + 2H_2O(l)$$

(a) You are to plan an experiment to determine the percentage of **copper(II) carbonate** in a sample of verdigris. Your method should involve the reaction of verdigris with excess dilute hydrochloric acid.

You are provided with the following materials.

- 0.5 g of verdigris
- 10.0 mol dm^{-3} hydrochloric acid, $HCl(aq)$
- commonly available laboratory reagents and equipment

You may assume that any other material present in verdigris is unaffected by heating and is not acidic or basic.

(i) Explain why a titration would **not** be a suitable method to determine the percentage of copper(II) carbonate in a sample of verdigris.

....

....

.... [1]

(ii) The 10.0 mol dm^{-3} $HCl(aq)$ is corrosive and too concentrated for use in the experiment.

Describe how you would accurately prepare 250 cm^3 of 0.500 mol dm^{-3} hydrochloric acid from the 10.0 mol dm^{-3} $HCl(aq)$ provided.

Include details of any apparatus, including their capacities in cm^3, you would use.

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.... [2]

(iii) Identify a dependent variable that you could measure to determine the percentage of copper(II) carbonate in verdigris.

Your answer should be based on a difference that you can identify between the reactions of copper(II) carbonate and copper(II) hydroxide with excess dilute hydrochloric acid.

....

....

.... [1]

(iv) Draw a diagram to show how you would set up apparatus and chemicals to measure the dependent variable identified in **(iii)**.

Label your diagram.

[2]

(v) Using the axes below, sketch a graph to show how the dependent variable you identified in **(iii)** would change during your experiment.

Extend the graph beyond the point at which the reaction is complete.

Label both axes.

[2]

(vi) A student carries out this experiment once.

Describe how this **one** experiment should be carried out to ensure that the results are as accurate as possible.

....

....

.... [1]

(vii) A student suspected that their 0.5 g sample of verdigris only contained $CuCO_3$.

Calculate the minimum volume, in cm^3, of $0.500\,mol\,dm^{-3}$ $HCl(aq)$ that would be needed for the complete reaction of the sample if the student was correct.

[M_r: $CuCO_3$ = 123.5]

volume of $0.500\,mol\,dm^{-3}$ $HCl(aq)$ = ... cm^3 [2]

(b) The following information gives some of the hazards associated with the chemicals used in the procedure.

Copper(II) carbonate hydroxide	The solid is classified as **health hazard** and is harmful if swallowed. Dispose of by reacting no more than 60 g in 1 dm^3 of warm 1 $mol\,dm^{-3}$ ethanoic acid before pouring down a foul-water drain.
Hydrochloric acid	Solutions equal to or more concentrated than 6.5 $mol\,dm^{-3}$ are classified as **corrosive**; solutions equal to or more concentrated than 2.7 $mol\,dm^{-3}$ but less concentrated than 6.5 $mol\,dm^{-3}$ are classified as **moderate hazard** and are irritant.

Describe **one** relevant precaution, other than eye protection and a lab coat, that should be taken to keep the risk associated with the chemicals used to a minimum. Explain your answer.

....

....

.... [1]

(c) Azurite is a blue copper-containing mineral. The copper compound in azurite has the formula $Cu_3(CO_3)_2(OH)_2$. This copper compound reacts with sulfuric acid according to the reaction shown.

$$Cu_3(CO_3)_2(OH)_2(s) + 3H_2SO_4(aq) \rightarrow 3CuSO_4(aq) + 2CO_2(g) + 4H_2O(l)$$

A student performed a series of titrations on 1.50 g samples of solid azurite using 0.400 mol dm^{-3} sulfuric acid.

It can be assumed that any other material present in azurite does not react with sulfuric acid.

The titration data is given in the table.

experiment	rough	1	2
final reading / cm^3	25.50	24.05	32.70
initial reading / cm^3	0.00	0.15	8.30
titre / cm^3	25.50	23.90	24.40

The indicator for the titration was bromophenol blue.

The student concluded that 24.15 cm^3 of 0.400 mol dm^{-3} sulfuric acid completely neutralised 1.50 g of azurite.

(i) Using the student's value of 24.15 cm^3, calculate the percentage by mass of $Cu_3(CO_3)_2(OH)_2$ in the sample of azurite.

Write your answer to **three significant figures**.

[M_r: $Cu_3(CO_3)_2(OH)_2$ = 344.5]

percentage by mass of $Cu_3(CO_3)_2(OH)_2$ in the sample of azurite = ... % [3]

(ii) Identify **two** possible problems with the student's titration **and** suggest improvements to it.

Problem 1 ....

....

Improvement 1 ....

....

Problem 2 ....

....

Improvement 2 ....

....
[3]

[Total: 18]

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2 Activated charcoal is a form of carbon with a very high surface area. It can be used to remove impurities from mixtures. It does this by a process called *adsorption*, where particles of the impurity bond (adsorb) to the activated charcoal surface.

A student wanted to determine the ability of activated charcoal to adsorb a blue dye (the impurity) from aqueous solution.

The equation that links the mass of activated charcoal with the amount of blue dye adsorbed is shown.

$$\log\left(\frac{D}{m}\right) = A + b\log[X]$$

D = difference in concentration of dye (in $g\,dm^{-3}$) before and after adsorption
m = mass of activated charcoal (in g)
$[X]$ = final concentration of dye (in $g\,dm^{-3}$) after adsorption
A and b are constants

The student used the following procedure to investigate the ability of activated charcoal to adsorb a blue dye from an aqueous solution.

- Place a $50.0\,cm^3$ sample of a $25.00\,g\,dm^{-3}$ solution of blue dye in a conical flask.
- Add a weighed mass of activated charcoal to the flask.
- Stir the contents of the flask for three minutes and then leave for one hour.
- Filter the mixture.
- Determine the final concentration of the blue dye, $[X]$, by colorimetry.
- Repeat the procedure using different masses of activated charcoal.

(a) The final concentrations of blue dye after carrying out the procedure, [*X*], are shown in the table.

(i) Process the results to complete the table.

Record your data to **two** decimal places.

mass of activated charcoal, *m* / g	initial concentration of blue dye / $g\,dm^{-3}$	final concentration of blue dye, [*X*] / $g\,dm^{-3}$	difference in concentration of blue dye, *D* / $g\,dm^{-3}$	$\frac{D}{m}$	$\log\left(\frac{D}{m}\right)$	$\log[X]$
0.20	25.00	0.96		120.20	2.08	
0.25	25.00	0.69		97.24	1.99	
0.30	25.00	0.60		81.33	1.91	
0.35	25.00	0.41		70.26	1.85	
0.40	25.00	0.33		61.68	1.79	
0.45	25.00	0.27		54.96	1.74	
0.50	25.00	0.23		49.54	1.69	
0.55	25.00	0.20		45.09	1.65	
0.60	25.00	0.17		41.38	1.62	

[3]

(ii) By considering the data in the first three columns, state the effect of increasing the mass of activated charcoal, *m*, on the amount of adsorption that occurs.

....

....

Explain this effect.

....

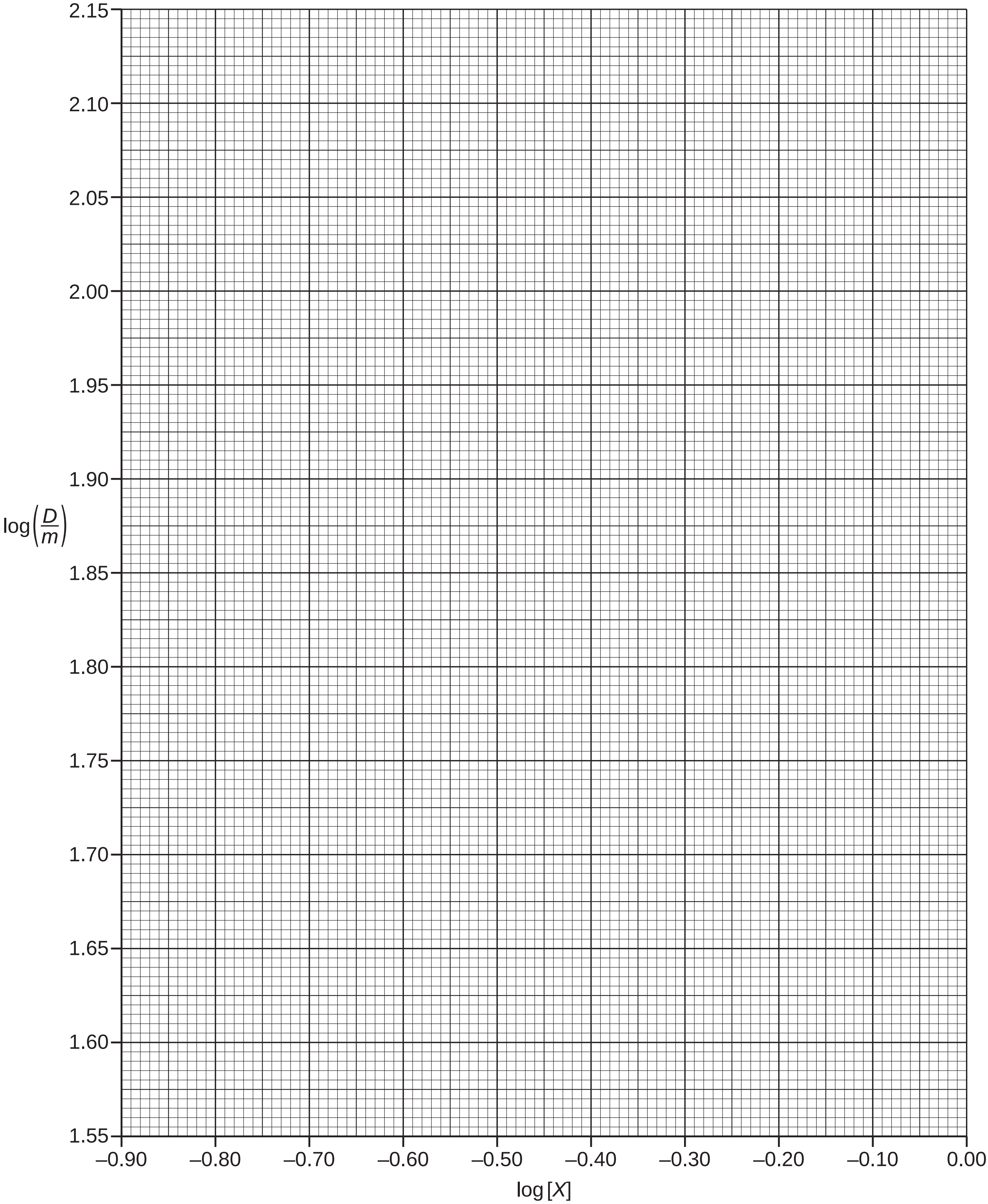
....

....

[2]

(b) Plot a graph on the grid to show the relationship between $\log\left(\frac{D}{m}\right)$ and $\log[X]$.

Use a cross (×) to plot each data point. Draw the straight line of best fit.



[2]

(c) Circle the most anomalous point on the graph.

Suggest a reason why this anomaly may have occurred during the experimental procedure.

....

....

.... [2]

(d) **(i)** Use the graph to determine the gradient of the best-fit line. State the co-ordinates of both points you used in your calculation.

Determine the value of the constant *b*.

co-ordinates 1 .... co-ordinates 2 ....

gradient = ...

b = ...
[2]

(ii) Use the graph to determine a value for *A*.

A = ... [1]

[Total: 12]