Cambridge International AS & A Level

Cambridge International Examinations
Cambridge International Advanced Subsidiary and Advanced Level

CANDIDATE NAME

CENTRE NUMBER

CANDIDATE NUMBER

5020590252

CHEMISTRY **9701/52**

Paper 5 Planning, Analysis and Evaluation **October/November 2018**

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 A sample of waste water contains calcium ions, copper(II) ions and lead(II) ions.

You are to plan an experimental procedure to separate the metal ions in the waste water sample by forming precipitates of the metal ions.

The table shows the numerical values of the solubility products, K_{sp}, of some compounds.
For example, the solubility product of calcium chloride, $K_{sp} = [Ca^{2+}][Cl^{-}]^2 = 2 \times 10^1\,mol^3\,dm^{-9}$.
The smaller the solubility product, the easier it is for a precipitate to form.

	K_{sp} values		
	Cl^-	CO_3^{2-}	S^{2-}
Ca^{2+}	2×10^1	5×10^{-9}	3×10^{-10}
Cu^{2+}	1×10^1	3×10^{-10}	6×10^{-36}
Pb^{2+}	2×10^{-5}	7×10^{-14}	3×10^{-28}

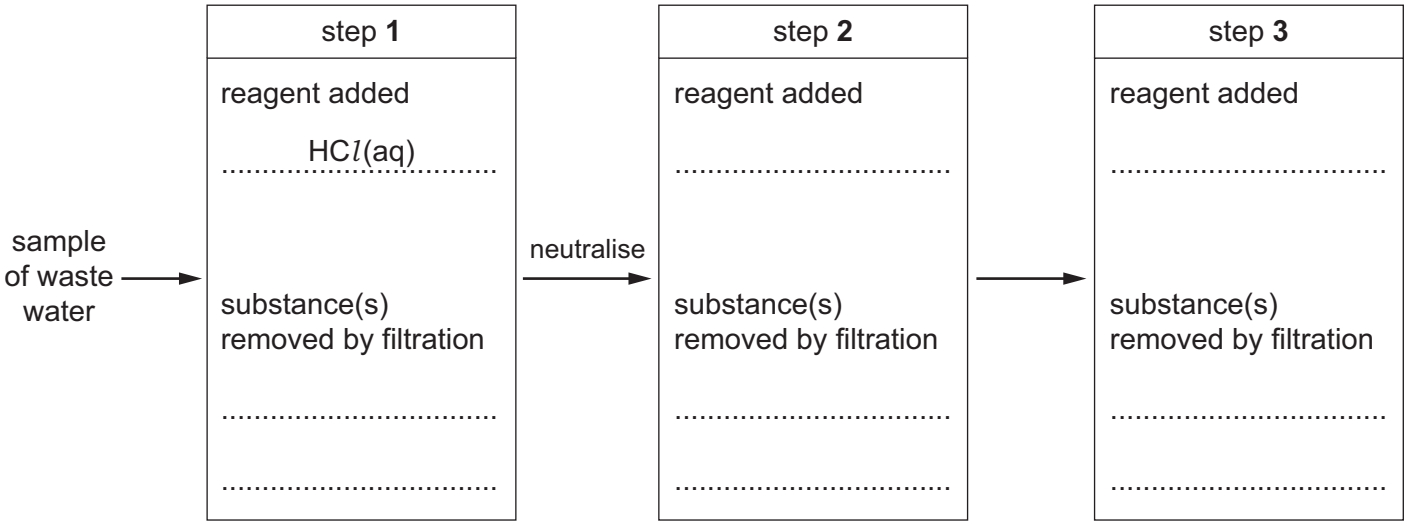
You are provided with

- a sample of waste water containing $Ca^{2+}(aq)$, $Cu^{2+}(aq)$ and $Pb^{2+}(aq)$,
- $HCl(aq)$,
- $(NH_4)_2CO_3(aq)$,
- $(NH_4)_2S(aq)$.

No other reagents should be used. Standard laboratory equipment is available.

(a) The flowchart below is provided to plan the order of steps for the separation by filtration of the precipitates from the sample of waste water.

Complete the flowchart. For each step state the reagent added and the substance(s) removed by filtration.



[3]

(b) After the substances formed in each step in **(a)** have been removed by filtration, a further drop of the reagent used for that step is added to the waste water sample.

Suggest why this is necessary.

.....

..... [1]

(c) Between steps **1** and **2**, the waste water sample is neutralised. This is so that steps **2** and **3** will work.

Suggest a reagent that should be added to neutralise the waste water sample. State how you could test that the waste water sample had been neutralised.

reagent .....

test .....

.....

.....
[2]

A student completes the reactions in **(a)** with a sample of waste water and obtains one of the precipitates produced, XCO_3.

(d) The student plans to calculate the concentration of X^{2+} ions present in this sample of waste water by measuring the mass loss on heating the freshly filtered sample of $XCO_3(s)$.

(i) Draw and label a diagram of the experimental set-up the student should use.
Your diagram should show how loss of solid during heating would be prevented.

[2]

The student weighs the XCO_3 precipitate and records its mass. The student then heats the precipitate strongly for five minutes and weighs it again. The student records the difference in mass and from this calculates $[X^{2+}]$.

The precipitate thermally decomposes according to the following equation.

$$XCO_3(s) \xrightarrow{\text{heat}} XO(s) + CO_2(g)$$

(ii) Identify **two** problems with this method. Explain the effect that each problem has on the calculated concentration of X^{2+}.

problem 1 .....

effect 1 .....

.....

problem 2 .....

effect 2 .....

.....

[4]

[Total: 12]

2 The hydrolysis of urea, $(NH_2)_2CO$, M_r = 60, is shown by the equation. The reaction is catalysed by the enzyme urease, when present in low concentrations.

$$(NH_2)_2CO + 2H_2O \rightarrow 2NH_4^+ + CO_3^{2-}$$

The formation of the NH_4^+ and CO_3^{2-} ions increases the conductivity of the solution. The increase in conductivity over time can be measured and the rate of hydrolysis can be determined from this.

A student plans to carry out this reaction using a 50 cm^3 sample of 5.00×10^{-3} mol dm^{-3} urea solution.

(a) The 5.00×10^{-3} mol dm^{-3} urea solution cannot be accurately prepared by dissolving urea in 50.0 cm^3 of water. A more concentrated solution is first prepared. This is then diluted to make the solution of the required concentration.

(i) Suggest why diluting a more concentrated solution is a more accurate method of preparing this solution than by dissolving urea in 50.0 cm^3 of water.

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.....

.....

..... [1]

(ii) Describe how you would accurately prepare exactly 100 cm^3 of 5.00×10^{-3} mol dm^{-3} urea solution, starting with 3.00 g of solid urea. Your method should use more than one volumetric flask, including one of capacity 1000 cm^3, and other suitable equipment.

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..... [3]

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[Turn over

(b) A student added a small amount of urease to a 50.0 cm^3 sample of the solution made in **(a)(ii)**. The conductivity of the solution was measured. The student obtained the results shown in the table. The student forgot to record the conductivity at 150 s. Conductivity is measured in $\mu S\,cm^{-1}$.

time, t / s	conductivity / $\mu S\,cm^{-1}$
0	0
30	55
60	110
90	160
120	215
150	–
180	320
210	375
240	425
270	480
300	530

(i) Plot a graph on the grid to show the relationship between time t and conductivity.

Use a cross (×) to plot each data point. Draw the straight line of best fit. [2]

(ii) Use the graph to determine the gradient of the best-fit line. State the co-ordinates of both points you used in your calculation.
Give your answer to **three significant figures**.

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

gradient = ... $\mu S\,cm^{-1}\,s^{-1}$
[2]

(iii) Use your graph to determine the conductivity of the solution at t = 150 s.

conductivity at 150 s = ... $\mu S\,cm^{-1}$ [1]

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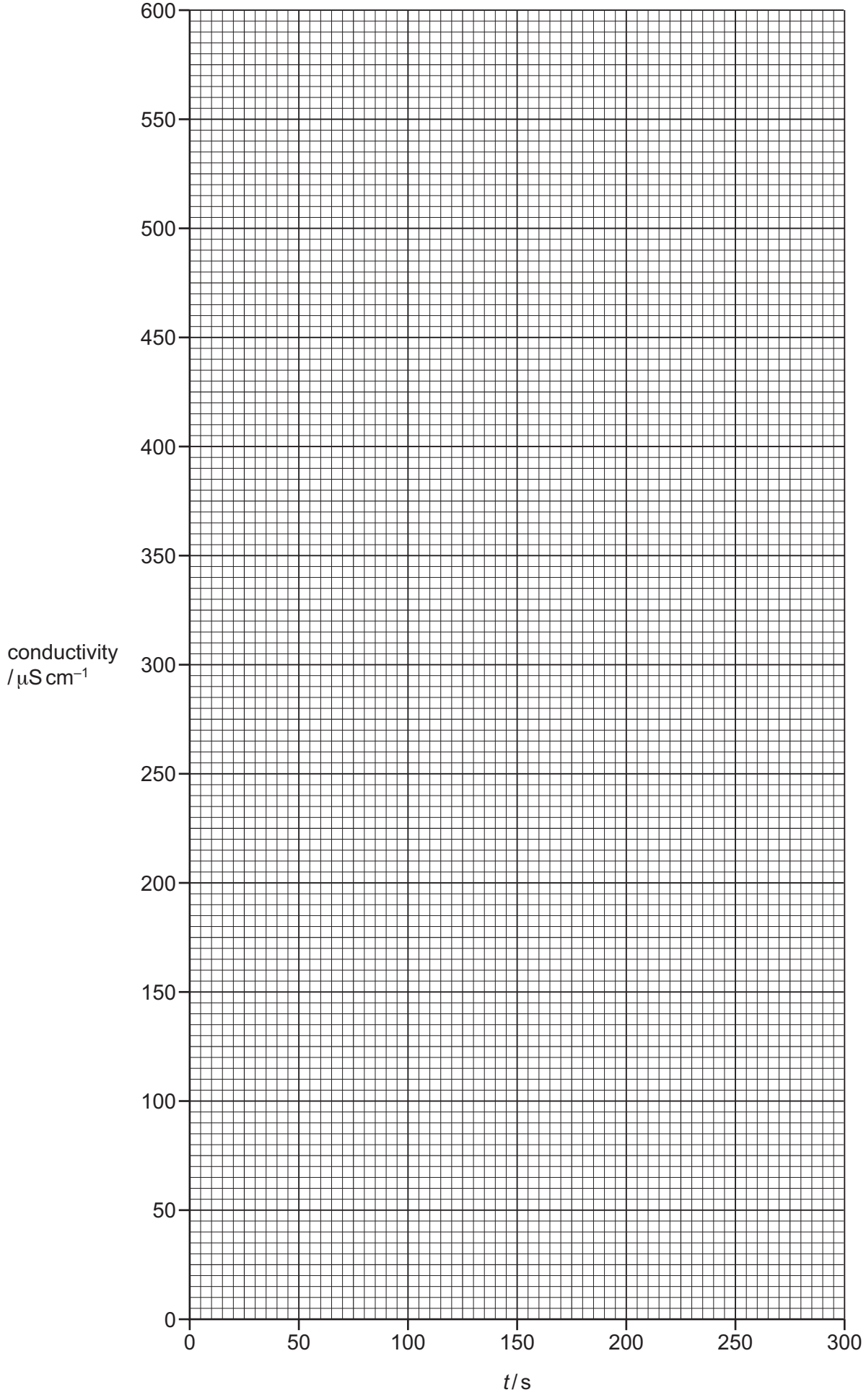

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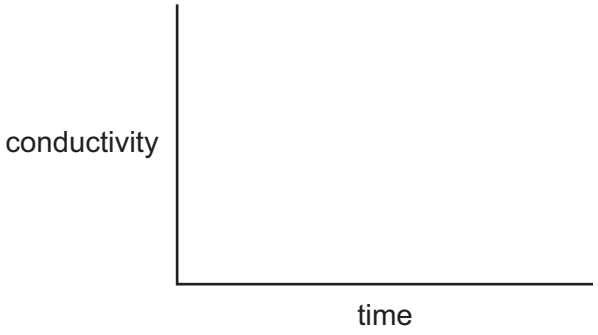
[Turn over

(c) In another experiment, a student added a small amount of urease to 50.0 cm^3 samples of urea of various concentrations and measured their conductivity until hydrolysis was complete.

(i) Sketch a graph on the axes below to show the variation in conductivity in **one** such experiment.

Explain the shape of your graph as hydrolysis reaches completion.



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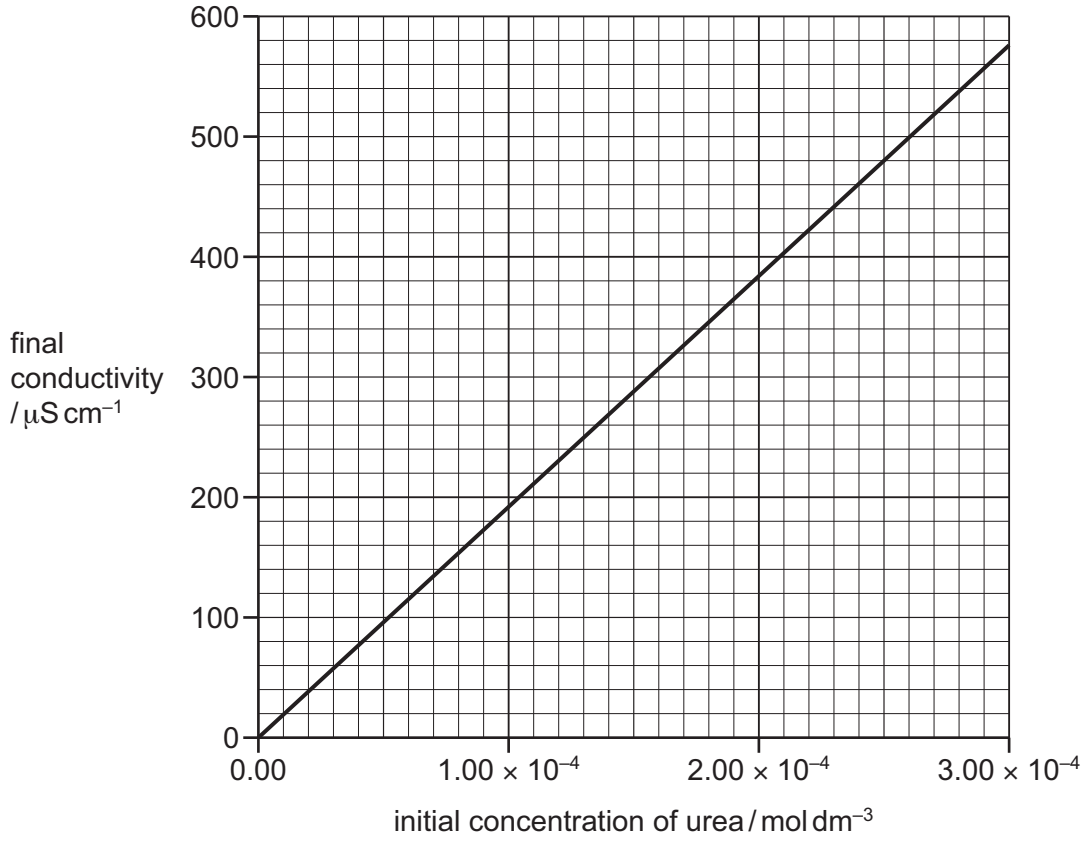
[2]

From their results, the student plotted the calibration graph, shown below, of final conductivity of solution against initial concentration of urea.



You are going to determine the average rate of hydrolysis over the first 150 s of the experiment in **(b)**.

(ii) Use the calibration graph to determine the initial concentration of urea that would give the same final conductivity as your answer to **(b)(iii)**.
(If you were unable to obtain an answer to **(b)(iii)** you should use the value of 350 μS cm^{-1}. This is not the correct value.)

initial concentration of urea = ... mol dm^{-3} [1]

(iii) Use your answer to **(c)(ii)** to calculate the average rate of hydrolysis of urea during the first 150 s. Determine the units of the rate of hydrolysis.

rate of hydrolysis = ... units = ... [2]

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[Turn over

(d) The student repeats the experiment in **(b)** using a different low concentration of urea solution.

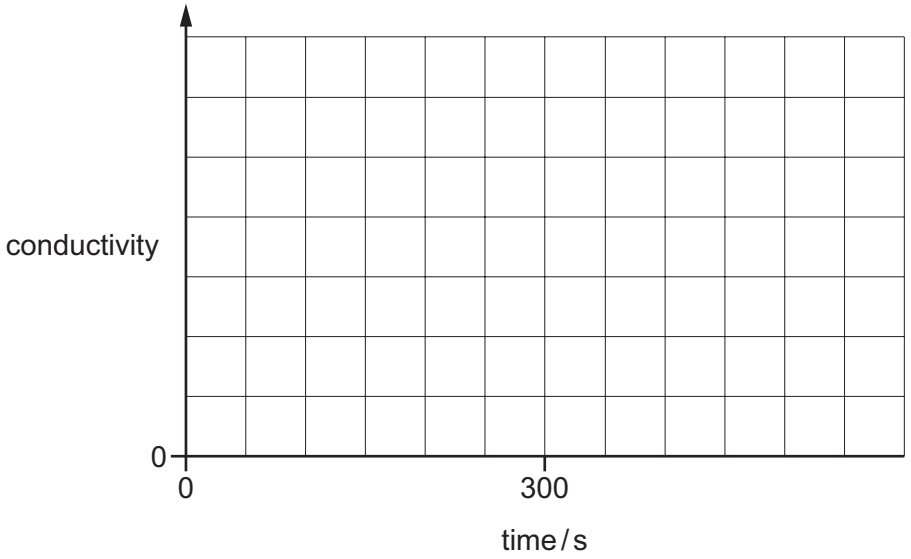
The student measures the conductivity of the solution for 300 s.

At 300 s, the student adds 1.0 cm^3 of 0.05 mol dm^{-3} aqueous silver nitrate, $AgNO_3(aq)$. The measured conductivity of the solution immediately increases.

$AgNO_3(aq)$ is known to prevent the enzyme urease from hydrolysing urea.

Using the axes below, sketch a graph to show how the conductivity of the solution changes during this experiment.

Extend the graph beyond the point at which $AgNO_3(aq)$ is added at 300 s.



[3]

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

silver nitrate	Solutions equal to or more concentrated than 0.18 mol dm^{-3} are classified as **corrosive** and **hazardous for the aquatic environment**; solutions equal to or more concentrated than 0.06 mol dm^{-3} but less concentrated than 0.18 mol dm^{-3} are classified as **moderate hazard** and **hazardous for the aquatic environment**; solutions less concentrated than 0.06 mol dm^{-3} are classified as **hazardous for the aquatic environment**.
urea	All solutions are low hazard.
urease	Concentrated solutions may produce allergic reactions. They can cause asthma and irritate the eyes, nose and skin. Dilute solutions are low hazard.

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.

precaution .....

.....

explanation .....

.....

[1]

[Total: 18]

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