Cambridge International Examinations
Cambridge International Advanced Subsidiary and Advanced Level

CANDIDATE NAME

CENTRE NUMBER

CANDIDATE NUMBER

5890562494

CHEMISTRY **9701/53**

Paper 5 Planning, Analysis and Evaluation **May/June 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 **10** printed pages and **2** blank pages.

IB18 06_9701_53/FP

1 The Faraday constant is the charge in coulombs, C, carried by 1 mole of electrons.

(a) A student plans an electrolysis experiment to determine the Faraday constant.

The student was supplied with the following.

- 1.0 mol dm^{-3} copper(II) sulfate
- clean, dry copper foil electrodes, labelled 'anode' and 'cathode'
- balance
- stop-clock
- ammeter
- other equipment suitable for carrying out electrolysis

Draw a labelled diagram of the apparatus and chemicals the student should use in their electrolysis experiment. Include in your diagram the circuit connecting the anode and cathode.

[2]

(b) Two of the hazards of using copper(II) sulfate solution are given below.

For each hazard, state a precaution, other than eye protection and a lab coat, that the student should take when carrying out the experiment.

hazard: copper(II) sulfate solution causes skin irritation

precaution ....

....

hazard: copper(II) sulfate solution is toxic to aquatic life

precaution ....

....
[2]

The student carried out the electrolysis for exactly 30 minutes with a current of 0.5A.

- After the electrolysis was finished, the student removed the electrodes.
- The electrodes were then carefully washed in water and then dipped in propanone.
- The electrodes were dried by allowing the propanone to evaporate.

(c) State the measurements the student would need to record to calculate the mass change of an electrode. Include the appropriate unit.

[1]

(d) Calculate the charge passed through the copper(II) sulfate solution during the electrolysis experiment using the formula shown.

charge (C) = current (A) × time (s)

charge passed = ... C [1]

(e) The mass change of the anode was –0.282 g.

Calculate the amount, in mol, of copper lost from the anode. Give your answer to 3 significant figures.
[A_r: Cu, 63.5]

moles of copper lost from the anode = ... mol [1]

(f) Use your answers to **(d)** and **(e)** to calculate the charge required to remove 1 mole of copper from the anode.

charge required to remove 1 mole of copper = ... C [1]

(g) The theoretical charge required to remove 1 mole of copper from the anode into solution as copper(II) ions is 193 000 C.
The Faraday constant is 96 500 C mol^{-1}.

Explain why the theoretical charge is twice the Faraday constant.

....

....

.... [1]

(h) A possible source of error is not drying the anode at the start of the experiment.

Explain the effect, if any, on the calculated value of the Faraday constant if the anode is wet at the beginning of the experiment but dry at the end.

effect ....

explanation ....

....

[1]

(i) The student wanted to ensure that the anode was completely dry at the end of the experiment and decided to evaporate off the propanone using a blue Bunsen flame. The student noticed some blackening of the surface of the copper.

Suggest what caused this blackening.

....

.... [1]

(j) The student calculated the mass change of the anode and the cathode after the experiment was complete.

mass change of anode = –0.282 g   mass change of cathode = +0.217 g

Suggest **one** reason why the mass gained at the cathode is **not** the same as the mass lost at the anode. Assume the student has recorded the mass changes correctly.

....

.... [1]

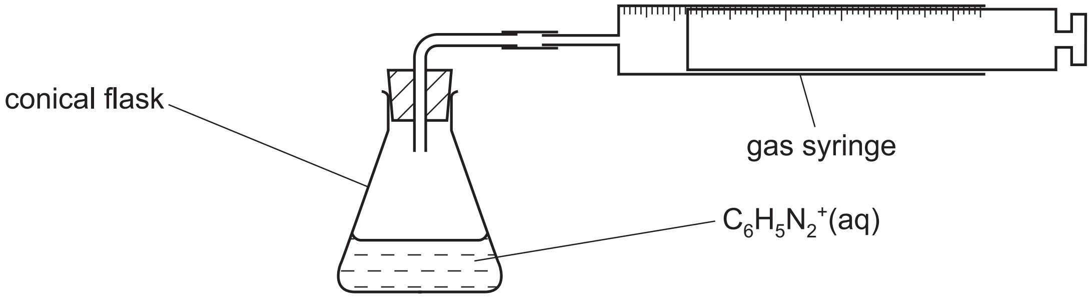
[Total: 12]

2 At temperatures above 5 °C, the benzenediazonium ion, $C_6H_5N_2^+$, reacts with water as shown.

$$C_6H_5N_2^+(aq) + H_2O(l) \rightarrow C_6H_5OH(aq) + N_2(g) + H^+(aq)$$

A student investigates this reaction by measuring the volume of nitrogen gas produced at regular time intervals.

The diagram shows the experimental set-up used to investigate this reaction.



(a) The student finds that the reaction is very slow, so decides to investigate the reaction at 30 °C.

Complete the diagram to show how the student could investigate this reaction at a constant 30 °C. [2]

(b) The student prepared a solution of $C_6H_5N_2^+(aq)$ at 5 °C. A 200.0 cm^3 sample of this solution was placed in a conical flask. The apparatus was allowed to equilibrate at 30 °C. The gas syringe was then connected, a stop-clock was started and readings of time and gas volume were taken. When the decomposition of the $C_6H_5N_2^+$ ion was complete (as shown by no more gas production) the final volume of $N_2(g)$ produced, V_{final}, was 72 cm^3.

(i) Show by calculation that when the stop-clock was started the concentration of $C_6H_5N_2^+(aq)$ was 0.0150 mol dm^{-3}.

[The molar volume of gas under room conditions is 24.0 dm^3.]

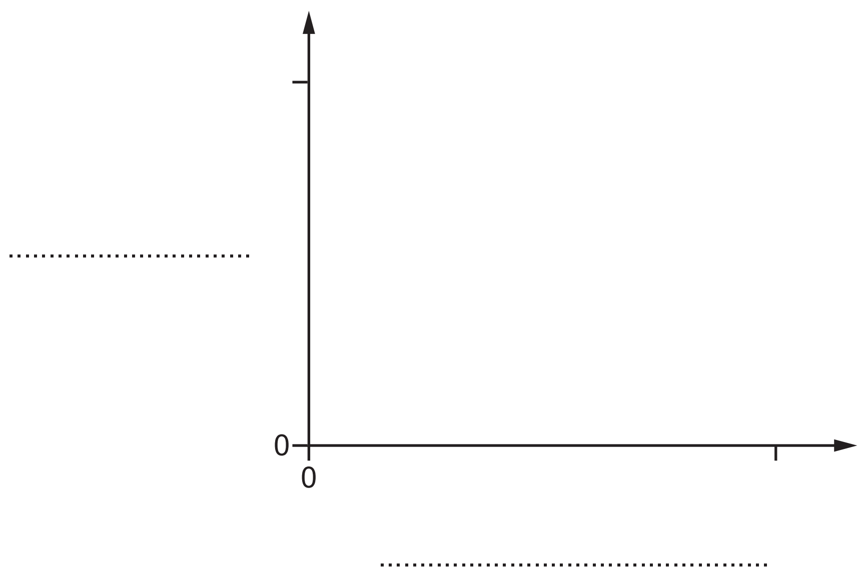
concentration of $C_6H_5N_2^+(aq)$ = ... mol dm^{-3} [2]

(ii) The volume of nitrogen produced is proportional to the amount of $C_6H_5N_2^+$ that reacts. As $C_6H_5N_2^+$ reacts, its concentration in the solution falls.

Using the axes shown, sketch a graph to show the change in volume of $N_2(g)$ produced with the change in concentration of $C_6H_5N_2^+(aq)$.

Label the axes $[C_6H_5N_2^+(aq)]$ / mol dm^{-3} and volume of $N_2(g)$ / cm^3, putting the independent variable on the *x*-axis.

Include on the axes the maximum values for concentration and volume where the lines on the axes are shown.



[2]

(c) The results the student obtained are shown in the table.

To calculate the concentration of $C_6H_5N_2^+(aq)$ the student used the following equation.

$$[C_6H_5N_2^+(aq)] = 0.0150 \times (1 - \frac{V}{V_{final}})$$

V = volume of $N_2(g)$ recorded at a specified time.

V_{final} = final volume of $N_2(g)$ at complete decomposition of $C_6H_5N_2^+$.

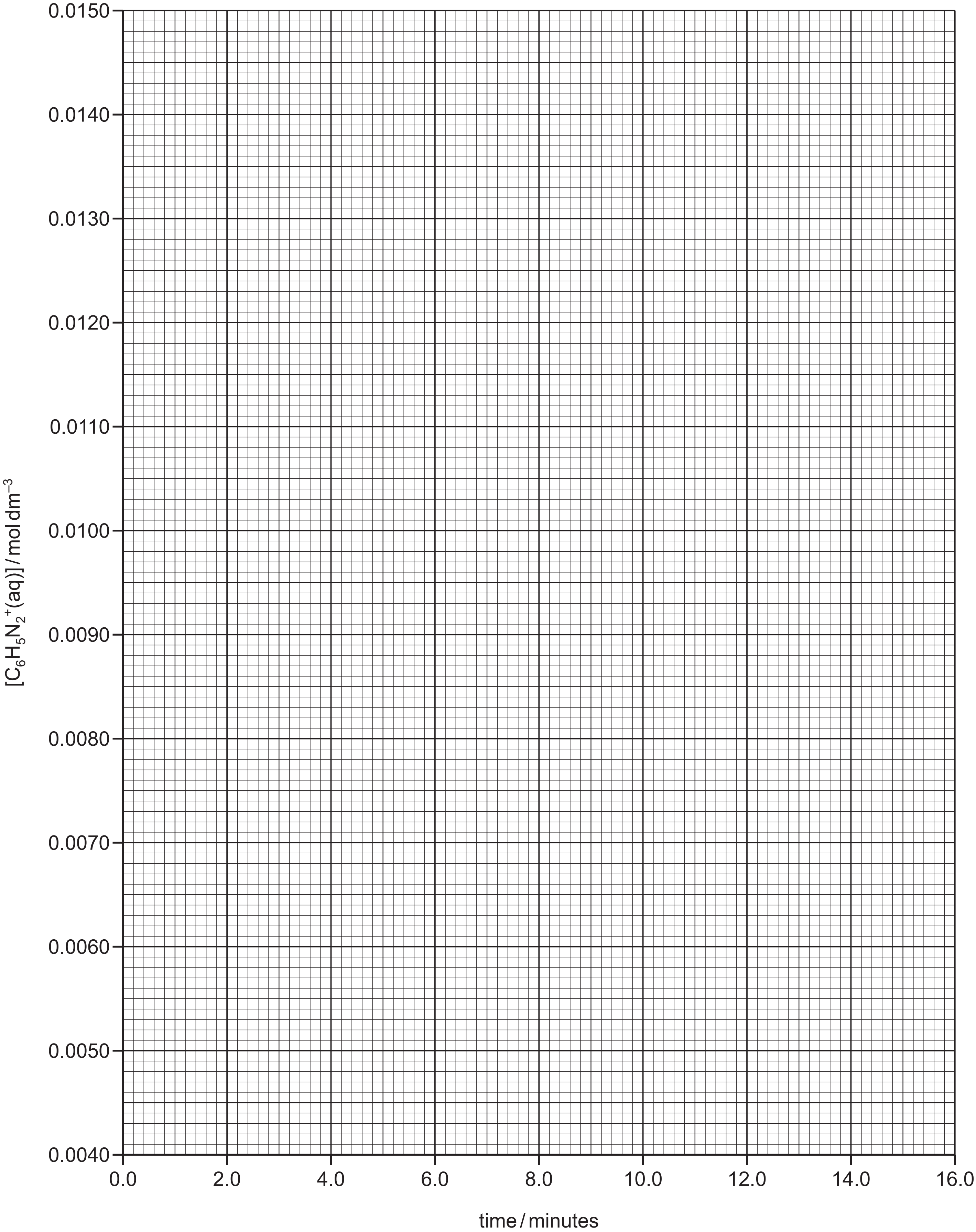
V_{final} is 72 cm^3.

Complete columns **C** and **D** to **three** significant figures. You may use the space below for any working.

A	B	C	D
time / minutes	volume of $N_2(g)$, V / cm^3	$\frac{V}{V_{final}}$	$[C_6H_5N_2^+(aq)]$ / mol dm^{-3}
0.0	0	0.000	0.0150
2.0	9	0.125	0.0150 × (1 – 0.125) = 0.0131
4.0	17		
6.0	24		
8.0	30		
10.0	35		
12.0	40		
14.0	44		
16.0	48		

[2]

(d) Plot a graph on the grid to show the relationship between $[C_6H_5N_2^+(aq)]$ and time.
Use a cross (×) to plot each data point. Draw a line of best fit.



[2]

(e) Draw a tangent at time = 0.0 on your graph and use the tangent to determine the initial rate of reaction. State the units of the initial rate of reaction.

State the co-ordinates of both points you used in your calculation.

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

initial rate of reaction = ...

units = ...

[4]

(f) Use your graph to complete the table and calculate the values of two half-lives. For the first half-life, concentrations have been chosen for you.

concentration 1	time 1	concentration 2	time 2	$t_{\frac{1}{2}}$
0.0120	....	0.0060	....	....
....	....	....	....	....

[3]

(g) State and explain what the values of the two half-lives suggest about the order of reaction with respect to $[C_6H_5N_2^+(aq)]$.

....

.... [1]

[Total: 18]

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