Cambridge International AS & A Level

Cambridge International Examinations
Cambridge International Advanced Subsidiary and Advanced Level

CANDIDATE NAME

CENTRE NUMBER

CANDIDATE NUMBER

3408813821

CHEMISTRY **9701/53**

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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1 The Finkelstein reaction is a nucleophilic substitution reaction in which a halogen atom in a halogenoalkane is replaced by another halogen atom. The reaction is carried out using dry propanone as a solvent.

One example of the Finkelstein reaction is given.

$$CH_3CH_2CH_2Br + NaI \rightleftharpoons CH_3CH_2CH_2I + NaBr$$

(a) (i) Explain why it is important for **dry** propanone to be used as a solvent for this reaction.

....

....

.... [1]

(ii) The solubilities of NaBr and NaI in propanone are shown.

compound	solubility at 25 °C in g / 100 g of propanone
NaBr	0.00841
NaI	39.9

Use this information to explain why, although the reaction between $CH_3CH_2CH_2Br$ and NaI is reversible, the reaction produces a very high yield.

....

....

....

....

....

.... [2]

(b) Some safety information for the organic compounds used in this reaction is shown.

- 1-bromopropane is **highly flammable** and **moderate health hazard**. It is irritating to eyes, the respiratory system and skin.
- 1-iodopropane is **flammable** and **moderate health hazard**. It is irritating to eyes, the respiratory system and skin.
- Propanone is **highly flammable** and **moderate health hazard**. It is irritating to eyes, and may cause dizziness and drowsiness.

Identify **two** different precautions, other than using protective equipment such as gloves, a lab coat or eye protection, that should be taken when carrying out this experiment. Explain each answer.

1 precaution ....

....

explanation ....

....

2 precaution ....

....

explanation ....

....

[2]

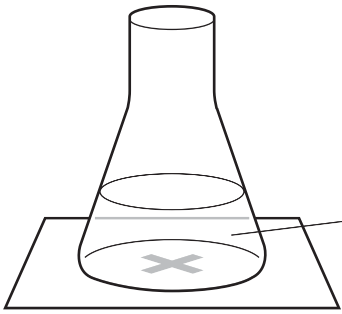
(c) A student plans an experiment to show that the rate of the reaction is proportional to the concentration of NaI.

Propanone is used as the solvent in this reaction.

$$CH_3CH_2CH_2Br(pr) + NaI(pr) \rightarrow CH_3CH_2CH_2I(pr) + NaBr(s)$$

(pr) = substance is dissolved in propanone

The student plans to record the time it takes for the solid formed to obscure a cross on a piece of paper below the conical flask, as shown.



To carry out this experiment, the following materials are available.

- $CH_3CH_2CH_2Br(l)$
- NaI(s)
- dry propanone, $CH_3COCH_3(l)$
- usual laboratory apparatus

(i) Calculate the masses of NaI(s) and $CH_3COCH_3(l)$ that would be needed to make 150 cm^3 of 0.50 mol dm^{-3} NaI(pr). Assume 150 cm^3 of propanone are required. Give your answers to **one decimal place**.

The density of $CH_3COCH_3(l)$ is 0.79 g cm^{-3}.

[A_r: Na, 23.0; I, 126.9]

mass of NaI(s) = ... g

mass of $CH_3COCH_3(l)$ = ... g

[2]

(ii) Part of the table the student used to record data is given.

Complete the table with appropriate volumes that the student could have used in four further experiments.

volume of 0.50 mol dm^{-3} NaI(pr) / cm^3	volume of $CH_3CH_2CH_2Br(l)$ / cm^3	volume of $CH_3COCH_3(l)$ / cm^3	total volume / cm^3	time / s	
10.0	2.0	30.0	42.0		....
					....
					....
					....
					....

[2]

(iii) The student uses the same experimental set-up each time.

In this experiment, identify the dependent variable.

.... [1]

(iv) Write an expression to show how the student could calculate the rate of the reaction.

[1]

(v) Identify the major source of inaccuracy of measurement in this reaction.

Suggest an improvement to the experiment to make it more accurate.

inaccuracy ....

....

improvement ....

....
[2]

(d) The reaction between $CH_3CH_2CH_2Br$ and NaI proceeds via an S_N2 mechanism.

The student repeated the experiment in **(c)** using an isomer of $CH_3CH_2CH_2Br$ that reacts via both S_N1 and S_N2 mechanisms.

State and explain whether the student will be able to show that the rate of this reaction is proportional to the concentration of NaI.

....

....

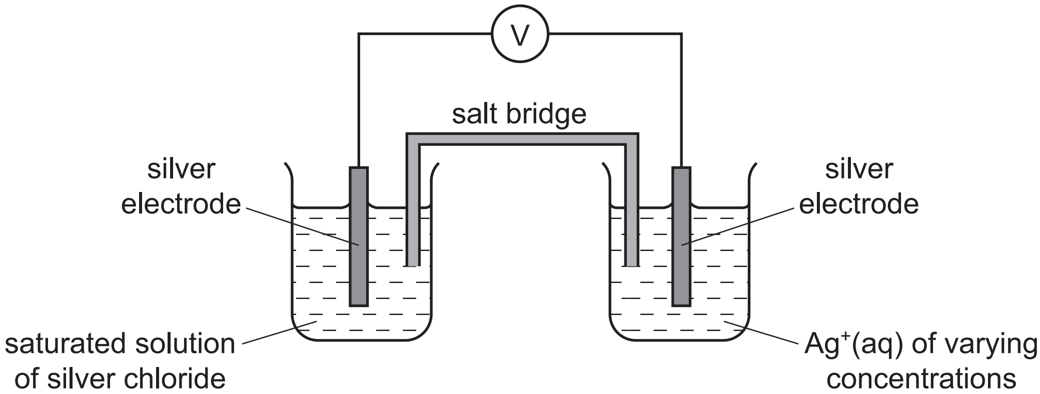
....

.... [1]

[Total: 14]

2 The solubility product, K_{sp}, of a sparingly soluble salt can be determined by measuring the cell potential of a cell known as a *concentration cell*. One of the half-cells uses a saturated solution of the salt as the electrolyte.

The K_{sp} of silver chloride, $AgCl$, can be measured using the apparatus shown.



The silver electrodes of the two half-cells were connected via a voltmeter, reading to three decimal places. This measured the cell potential of the concentration cell.

The half-cells were kept at a temperature of 40 °C. Under these conditions, the relationship between cell potential, E_{cell}, and $[Ag^+(aq)]$ is

$$16.1E_{cell} = \log C_{sat} - \log [Ag^+(aq)]$$

C_{sat} is the concentration of the saturated solution of silver chloride

(a) **(i)** The solutions in the half-cells need to be kept at 40 °C.

Explain how you would do this.

....

.... [1]

(ii) If the temperature was maintained at 40 °C, over time the reading on the voltmeter would change.

Suggest **one** reason why.

....

.... [1]

The cell potential was measured for various concentrations of $Ag^+(aq)$ and the results obtained are shown in the table.

(b) Complete the fourth and fifth columns of the table.

Give each answer to **two decimal places**.

experiment	$[Ag^+(aq)]$ / mol dm^{-3}	E_{cell} / V	$-\log [Ag^+(aq)]$	$16.1E_{cell}$ / V
1	0.00100	–0.097		
2	0.00500	–0.140		
3	0.0100	–0.159		
4	0.0250	–0.171		
5	0.0500	–0.202		
6	0.100	–0.221		
7	0.200	–0.239		
8	0.500	–0.264		
9	1.50	–0.294		

[2]

(c) (i) On the grid on page 9, plot a graph of $16.1E_{cell}$ against $-\log [Ag^+(aq)]$.

Draw a line of best fit. [2]

(ii) Circle the single most anomalous point on the graph.

The temperature of the half-cells was maintained at 40 °C. Suggest what error in the experimental set-up may have caused the anomaly.

....

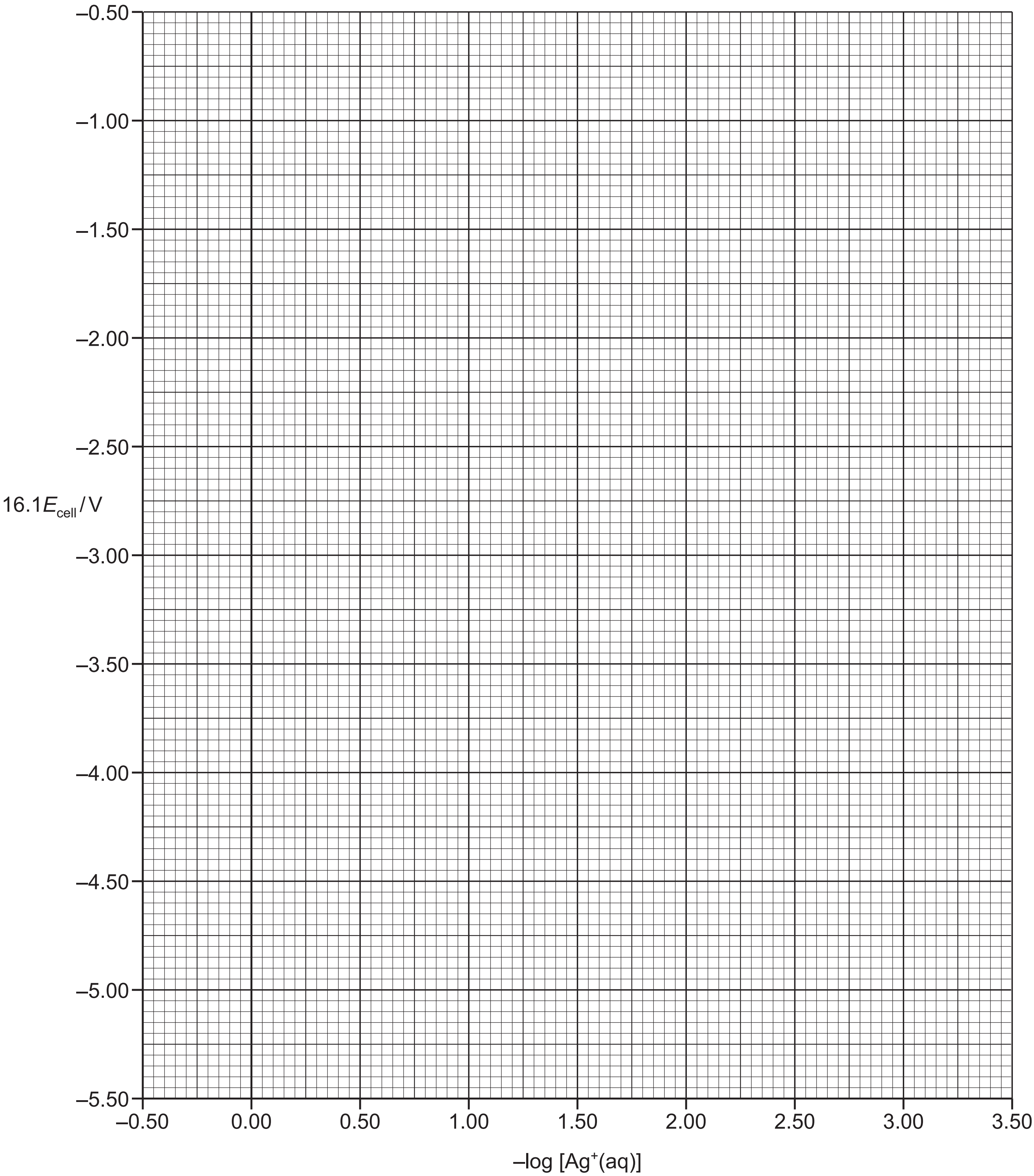
....

.... [2]

(iii) Use your graph and the equation to determine a value for $\log C_{sat}$.

$$16.1E_{cell} = \log C_{sat} - \log [Ag^+(aq)]$$

$\log C_{sat}$ = ... [1]


–0.50
–1.00
–1.50
–2.00
–2.50
16.1E_{cell} / V
–3.00
–3.50
–4.00
–4.50
–5.00
–5.50
–0.50
0.00
0.50
1.00
1.50
2.00
2.50
3.00
3.50
–log [Ag^+(aq)]

(d) To carry out these experiments, $Ag^+(aq)$ of concentration 2.0 mol dm^{-3} was prepared.

(i) For experiment 6, calculate the volume of 2.0 mol dm^{-3} $Ag^+(aq)$ needed to prepare exactly 250.0 cm^3 of $Ag^+(aq)$ in a 250.0 cm^3 volumetric flask.

volume = ... cm^3 [1]

(ii) Name a suitable piece of apparatus which could be used to measure the volume calculated in **(i)**.

....[1]

(e) **(i)** The relationship between the solubility product, K_{sp}, and the concentration of the saturated solution of silver chloride, C_{sat}, is shown.

$$K_{sp} = C_{sat}^{\;2}$$

Use this equation and your answer to **(c)(iii)** to calculate a value for K_{sp}.

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

(If you have no answer for **(c)(iii)**, use a value of –4.20 but this is **not** the true value.)

K_{sp} = ... [2]

(ii) The solubility of AgCl increases with temperature.

Using the axes below, sketch a graph to show how the K_{sp} of AgCl varies with temperature.

Label both axes.

[1]

(f) The salt bridge in a concentration cell commonly contains a solution of one of the following compounds.

potassium chloride potassium nitrate sodium chloride

Identify which, if any, of these compounds would **not** be suitable for use in the salt bridge in this experiment.

Explain your answer.

....

....

.... [2]

[Total: 16]

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