Cambridge International AS & A Level

Cambridge International Examinations
Cambridge International Advanced Subsidiary and Advanced Level

CANDIDATE NAME									
CENTRE NUMBER						CANDIDATE NUMBER			

9778813827

CHEMISTRY **9701/51**

Paper 5 Planning, Analysis and Evaluation **October/November 2016**

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 When hydrated barium chloride, $BaCl_2.\mathbf{x}H_2O$, dissolves in water, $Ba^{2+}(aq)$ and $Cl^-(aq)$ ions are formed.

The concentration of chloride ions in solution can be determined by titration with aqueous silver nitrate of known concentration.

$$Ag^+(aq) + Cl^-(aq) \rightarrow AgCl(s)$$

The indicator for the reaction is aqueous potassium chromate(VI), $K_2CrO_4(aq)$. At the endpoint of the titration, it forms a red precipitate in the presence of excess silver ions.

(a) The solubilities, in $g\,dm^{-3}$, of different ionic compounds at 20 °C are given in the table below.

	anion		
cation	Cl^-	CrO_4^{2-}	SO_4^{2-}
Ag^+	0.0019	0.022	293
Ba^{2+}	358	0.0028	0.00245

With reference to these data, where relevant, answer the following questions.

(i) Name the red precipitate and give an equation for its formation.

name: .....

equation: .....
[2]

Sulfuric acid must be added to the solution to prevent the $Ba^{2+}(aq)$ ions from interfering with the action of the potassium chromate(VI) indicator.

(ii) How would $Ba^{2+}(aq)$ ions interfere with the action of this indicator?

.....

..... [1]

(iii) How does the addition of sulfuric acid prevent $Ba^{2+}(aq)$ ions from interfering with the action of this indicator?

.....

..... [1]

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(b) In an initial rough titration, excess silver nitrate solution is added so that the endpoint is exceeded.

Draw a sketch graph to show how the mass of silver chloride varies with the volume of silver nitrate added.

Label both axes.



[2]

(c) You are to plan a titration experiment to determine the value of **x** in $BaCl_2.\mathbf{x}H_2O$.

You are provided with the following materials.

3.00 g of hydrated barium chloride, $BaCl_2.\mathbf{x}H_2O$
0.050 mol dm^{-3} aqueous silver nitrate
1.0 mol dm^{-3} potassium chromate(VI) solution
1.0 mol dm^{-3} sulfuric acid

(i) Name **three** pieces of volumetric apparatus you would use, with their capacities in cm^3.

1 .....

2 .....

3 .....
[2]

(ii) Describe how you would make a solution of barium chloride that is suitable for use in your titration.

.....

.....

.....

.....

.....

..... [2]

(iii) A known volume of barium chloride solution is transferred to a conical flask.

In what order should the other three solutions then be added to the flask?

first .....

second .....

third .....
[1]

(iv) How would you ensure that your titration result is reliable?

.....

..... [1]

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(v) In another experiment, a student dissolved 3.13 g of hydrated barium chloride, $BaCl_2.\mathbf{x}H_2O$, in distilled water to give 1.00 dm^3 of solution.

It was calculated that the concentration of $Ba^{2+}(aq)$ ions was 0.0128 mol dm^{-3}.

Determine the value of **x** in $BaCl_2.\mathbf{x}H_2O$.

[A_r: Ba, 137.3; Cl, 35.5; H, 1.0; O, 16.0]

x = ...
[2]

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

Barium chloride	Solid barium chloride is classified as **toxic**. Solutions equal to or more concentrated than 0.4 mol dm^{-3} are classified as **moderate hazard** and are harmful if swallowed. Solutions less concentrated than 0.4 mol dm^{-3} are classified as non-hazardous.
Potassium chromate(VI)	All solutions more concentrated than 0.9 mol dm^{-3} are classified as **health hazard**. They may cause skin, eye and respiratory irritation.
Silver nitrate	Solutions equal to or more concentrated than 0.18 mol dm^{-3} are classified as **corrosive**. Solutions equal to or more concentrated than 0.06 mol dm^{-3} but less than 0.18 mol dm^{-3} are classified as **moderate hazard** and cause skin and eye irritation. Solutions less concentrated than 0.06 mol dm^{-3} are classified as non-hazardous.

Identify **one** hazard that must be considered when planning the experiment and describe a precaution, other than eye protection, that should be taken to keep risks from this hazard to a minimum.

hazard: .....

precaution: .....

.....
[1]

[Total: 15]

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[Turn over

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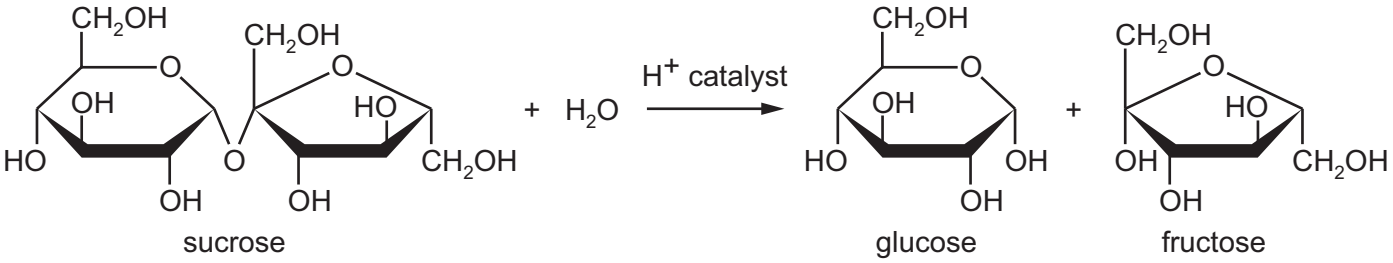
2 Sucrose, $C_{12}H_{22}O_{11}$, is a naturally occurring sugar found in sugarcane and many fruits. It can be hydrolysed in acidic solution to give glucose and fructose. All three molecules are chiral and will rotate the plane of polarised light. The degree of rotation is known as the **optical rotation**, α.



sucrose glucose fructose

In the presence of excess water, the reaction can be considered to be first order with respect to sucrose concentration.

The progress of the reaction can be monitored using a polarimeter, which measures the optical rotation, α, of the solution. The more concentrated the solution, the greater the optical rotation of the solution.

The concentration of sucrose at time *t* can be represented as $(\alpha - \alpha_{final})$, where α_{final} is the optical rotation of the solution after 6 hours.

The mathematical relationship is given by the following equation.

$$\log_{10}(\alpha - \alpha_{final}) = A - \frac{kt}{2.30}$$

A is a constant.
k is the rate constant.

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(a) The experimentally determined values of optical rotation during the hydrolysis of sucrose at 298 K are recorded below.

Process the results to allow you to plot a graph of $\log_{10}(\alpha - \alpha_{final})$ against time, *t*.

Calculate $(\alpha - \alpha_{final})$ and record it to 1 decimal place.

Calculate $\log_{10}(\alpha - \alpha_{final})$ and record it to 2 decimal places.

time / s	optical rotation, α	$(\alpha - \alpha_{final})$	$\log_{10}(\alpha - \alpha_{final})$
0	39.9		
300	29.1		
600	21.3		
900	15.5		
1200	10.6		
1500	6.2		
1800	2.4		
2100	–0.3		
2400	–2.5		
2700	–4.5		

α_{final}	–12.0

[2]

(b) (i) Plot a graph on the grid on page 9 to show how $\log_{10}(\alpha - \alpha_{final})$ varies with time, *t*. Use a cross (×) to plot each data point. Draw the line of best fit. [2]

(ii) State and explain whether the results and your graph confirm the relationship $\log_{10}(\alpha - \alpha_{final}) = A - \frac{kt}{2.30}$.

.....

.....

..... [1]

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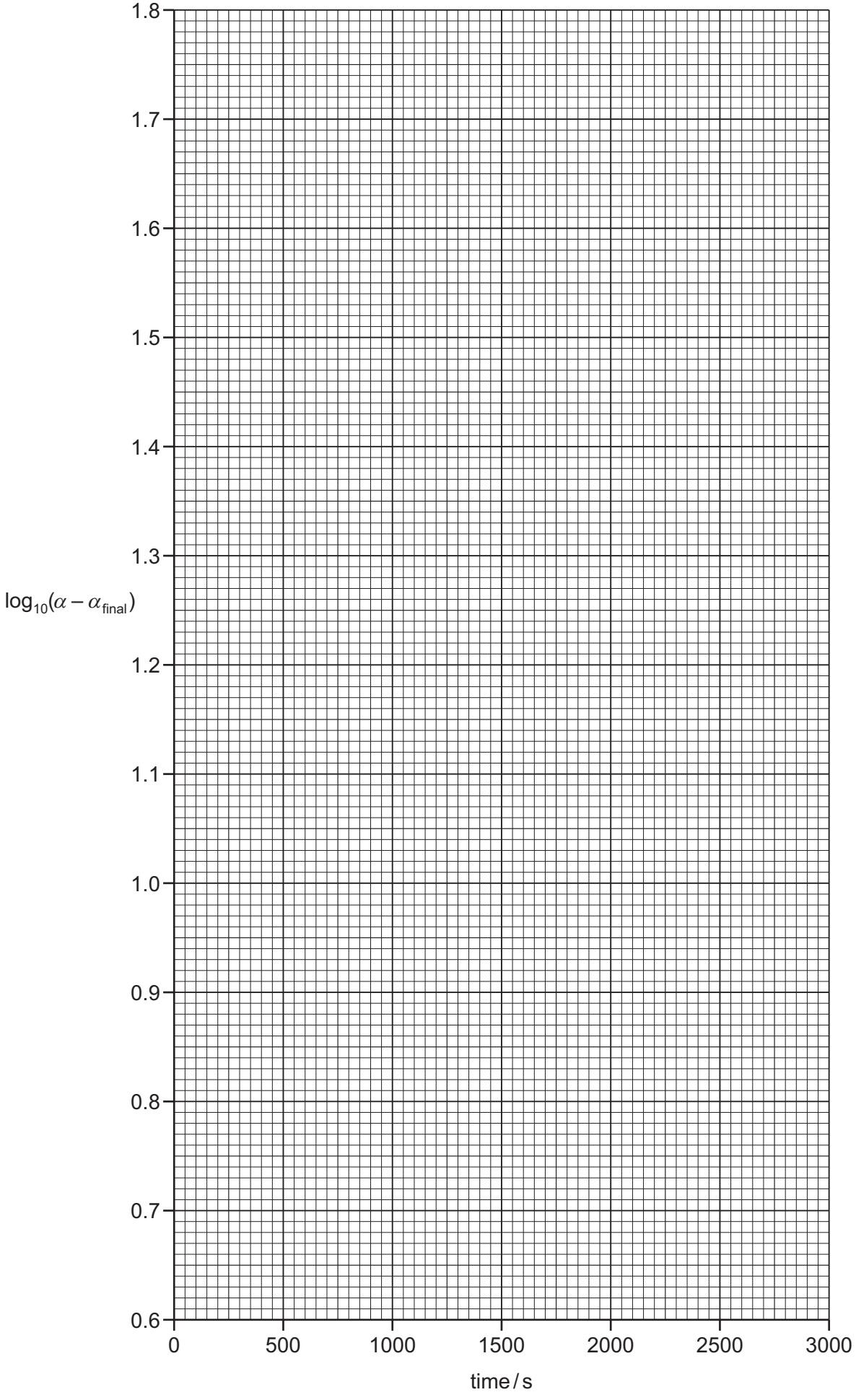

1.8
1.7
1.6
1.5
1.4
1.3
log10(α – αfinal)
1.2
1.1
1.0
0.9
0.8
0.7
0.6
0
500
1000
1500
2000
2500
3000
time / s

(c) (i) Determine the gradient of the graph.
State the co-ordinates of both points you used for your calculation.
Record the value of the gradient to **three significant figures**.

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

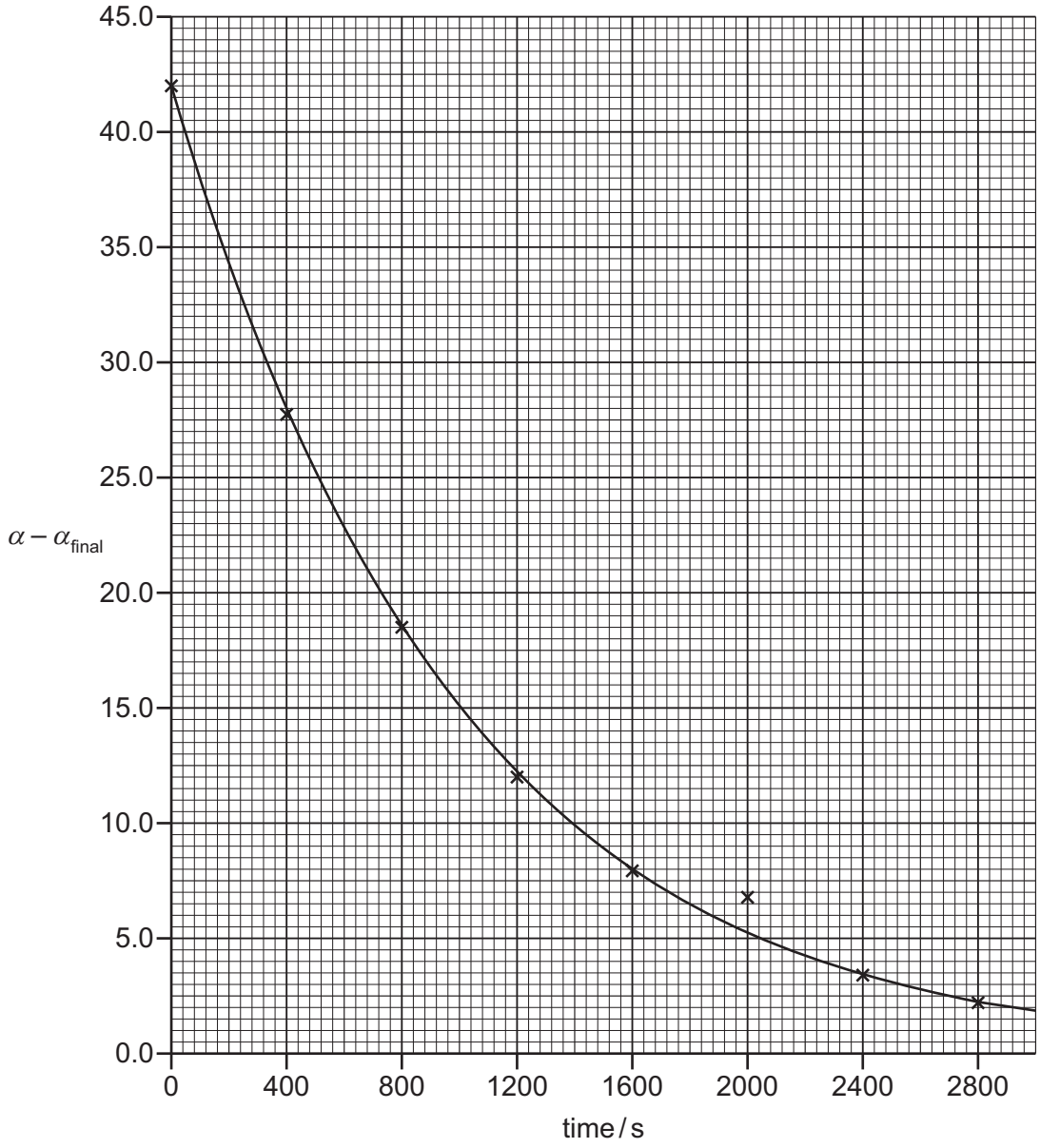
gradient = ... s^{-1}
[2]

(ii) Use the gradient value to calculate a value for k in the expression shown.

$$\log_{10}(\alpha - \alpha_{final}) = A - \frac{kt}{2.30}$$

[2]

(d) The graph below shows the results obtained from a second hydrolysis of sucrose reaction performed at a different temperature.



(i) The point at time = 2000 s is considered to be anomalous.
Suggest what caused the anomaly.

.....

.....

..... [1]

(ii) Use the graph to determine the half-life, $t_{½}$, of this reaction.
State the co-ordinates of both points you used in your calculation.

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

half-life = ... s [2]

(iii) For a first-order reaction, the following relationship exists.

$$\text{half-life, } t_{½} = \frac{0.693}{k'}$$

Use this relationship and your answer to **(ii)** to determine k', the rate constant for this second hydrolysis reaction.
If you have been unable to determine the half-life of the reaction in **(ii)**, you may use the value $t_{½}$ = 500 s, though this is not the correct answer.

k' = ... s^{-1} [1]

(iv) State whether the temperature of the second reaction was higher or lower than that of the first.
Explain your answer with reference to the answers you obtained in **(c)(ii)** and **(d)(iii)**.
If you have been unable to calculate a value for k in **(c)(ii)**, you may use the value $k = 8.00 \times 10^{-4}$, though this is not the correct answer.

.....

.....

..... [1]

(v) Would the value of the half-life change if the reaction were repeated with twice the initial concentration of sucrose? Give a reason for your answer.

.....

.....

..... [1]

[Total: 15]

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