Cambridge International AS & A Level

Cambridge International Examinations
Cambridge International Advanced Subsidiary and Advanced Level

CANDIDATE NAME

CENTRE NUMBER

CANDIDATE NUMBER

CHEMISTRY **9701/52**

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 **12** printed pages.

CAMBRIDGE International Examinations

1 Titrations using ethylenediaminetetraacetic acid (EDTA) can be used to determine the concentration of metal ions in solution, such as $Zn^{2+}(aq)$.

A solution of EDTA is usually prepared from the hydrated disodium salt, $Na_2H_2Y.2H_2O$. The anion of EDTA is H_2Y^{2-}, where Y represents the organic part of the ion.

The equation for the reaction between $Zn^{2+}(aq)$ and EDTA is shown.

$$Zn^{2+}(aq) + H_2Y^{2-}(aq) \rightarrow ZnY^{2-}(aq) + 2H^+(aq)$$

The indicator for the reaction is Solochrome Black, which changes colour at the endpoint from purple to blue. The indicator only works at pH 10, so a buffer solution is added to the metal ion solution to maintain the pH.

(a) Explain why the pH would change during the titration if the buffer were not present.

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.....

..... [1]

(b) You are to plan a titration experiment to determine the concentration of zinc ions in a solution of zinc sulfate of concentration approximately 0.1 mol dm^{-3}.

You are provided with the following materials.

20.0 g of hydrated disodium EDTA, $Na_2H_2Y.2H_2O$ (M_r = 372.2)
aqueous zinc sulfate of approximate concentration 0.1 mol dm^{-3}
buffer solution, pH 10
Solochrome Black indicator solution

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

1 .....

2 .....

3 .....
[2]

(ii) Calculate the mass of hydrated disodium EDTA that would be required for the preparation of a standard solution of concentration 0.100 mol dm^{-3}, using the apparatus you have specified in **(i)**.

mass of hydrated disodium EDTA = ... g [1]

(iii) Describe how you would prepare this standard solution for use in your titration.

.....

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..... [2]

(iv) After you have performed a rough titration, how would you ensure that your next titration is accurate?

.....

..... [1]

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

.....

..... [1]

(c) The term *hard water* is used to describe water containing the dissolved metal ions, $Ca^{2+}(aq)$ and $Mg^{2+}(aq)$. Both of these metal ions react with EDTA anions, H_2Y^{2-}.

$$Ca^{2+}(aq) + Mg^{2+}(aq) + 2H_2Y^{2-}(aq) \rightarrow CaY^{2-}(aq) + MgY^{2-}(aq) + 4H^{+}(aq)$$

In an experiment to determine the concentration of each of these metal ions, two separate titrations with EDTA need to be performed.

For titration **1**, a 25.0 cm^3 sample of hard water is titrated with 0.0100 $mol\,dm^{-3}$ EDTA solution using Solochrome Black solution as indicator.

For titration **2**, another 25.0 cm^3 sample of the same hard water is first treated with excess 2 $mol\,dm^{-3}$ NaOH(aq) which precipitates **all** of the $Mg^{2+}(aq)$ ions as $Mg(OH)_2(s)$. After this treatment, no $Mg^{2+}(aq)$ ions remain in solution, leaving only dissolved $Ca^{2+}(aq)$ ions in solution. This solution is then titrated with 0.0100 $mol\,dm^{-3}$ EDTA solution using Solochrome Black solution as indicator.

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

Sodium hydroxide	Solutions equal to or more concentrated than 0.5 $mol\,dm^{-3}$ are classified as **corrosive**.
Solochrome Black	Solid Solochrome Black is classified as **health hazard** and is irritating to eyes, respiratory system and skin. All solutions are made up in ethanol and so are classified as **flammable** and **health hazard**.

(i) 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]

(ii) Results obtained from this experiment are shown.

titre **1**, 22.70 cm^3 titre **2**, 16.60 cm^3

Use the results of the titrations to determine the concentrations of $Ca^{2+}(aq)$ and $Mg^{2+}(aq)$ in the hard water.

concentration of $Ca^{2+}(aq)$ ..... $mol\,dm^{-3}$

concentration of $Mg^{2+}(aq)$ ..... $mol\,dm^{-3}$
[4]

[Total: 13]

2 Benzenediazonium chloride, $C_6H_5N_2Cl$, is readily hydrolysed at temperatures above 5 °C, forming phenol, nitrogen gas and hydrochloric acid.

$$C_6H_5N_2Cl(aq) + H_2O(l) \rightarrow C_6H_5OH(aq) + N_2(g) + HCl(aq)$$

The progress of the reaction can be monitored by measuring the volume of gas produced over time. The volume of gas produced, V, after time, t, is proportional to the amount of benzenediazonium chloride that has been hydrolysed. The final volume of gas produced, V_{final}, is proportional to the original concentration of benzenediazonium chloride.

The order of reaction can be determined from these results.

(a) (i) The experimentally determined volumes of gas produced during the hydrolysis of benzenediazonium chloride at 50 °C are recorded below.

Process the results to allow you to plot a graph of $(V_{final} - V)$ against time, t.

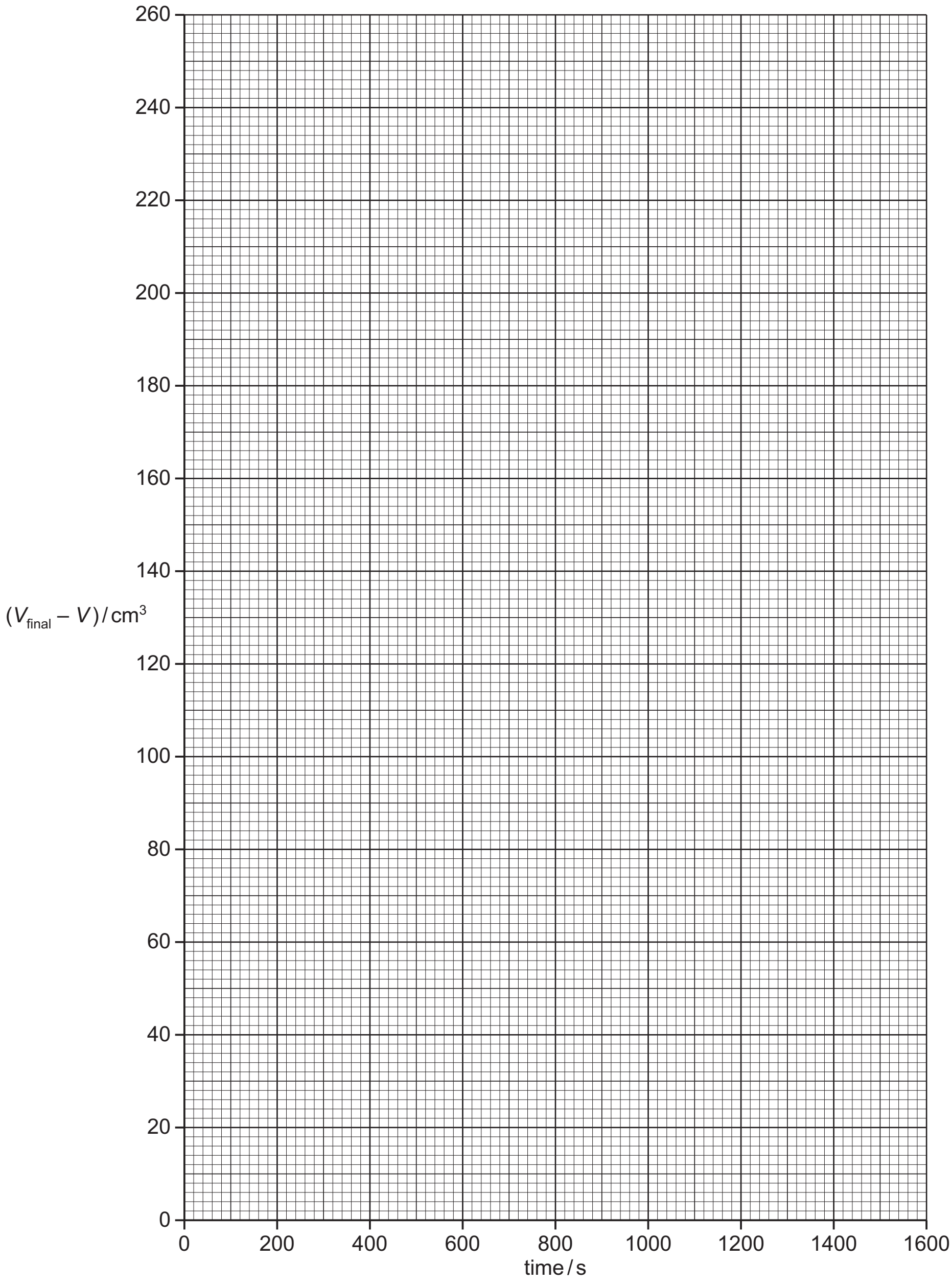
$V_{final} = 252\,cm^3$

time / s	volume, V / cm^3	$(V_{final} - V)$ / cm^3
0	0	
150	32	
300	62	
450	87	
600	110	
750	129	
900	146	
1050	160	
1200	173	
1350	184	
1500	193	

[1]

(ii) Plot a graph to show how $(V_{final} - V)/cm^3$ varies with time/s.

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



[2]

(iii) Do you think the results obtained in **(i)** are reliable? Explain your answer.

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..... [1]

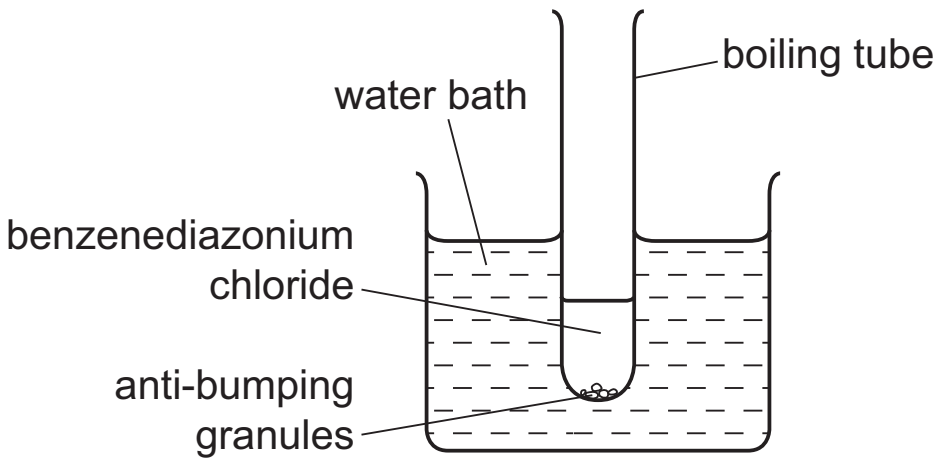
(iv) Use the graph to determine the half-life, $t_{½}$, of this reaction.

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

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

half-life = ... s
[2]

(b) A student set up an experiment to determine the order of the reaction in **(a)**. Part of the experimental set-up is shown below.



(i) Complete the diagram above to show the experimental set-up the student could have used to collect and measure the volume of gas evolved by the reaction. [2]

(ii) The water bath was set at 60 °C.

At a reaction temperature of 60 °C, the measurements made would be less accurate than measurements made at room temperature.

State why the measurements made at a higher temperature are less accurate.

.....

.....

State the effect this will have on the values of $V_{final} - V$.

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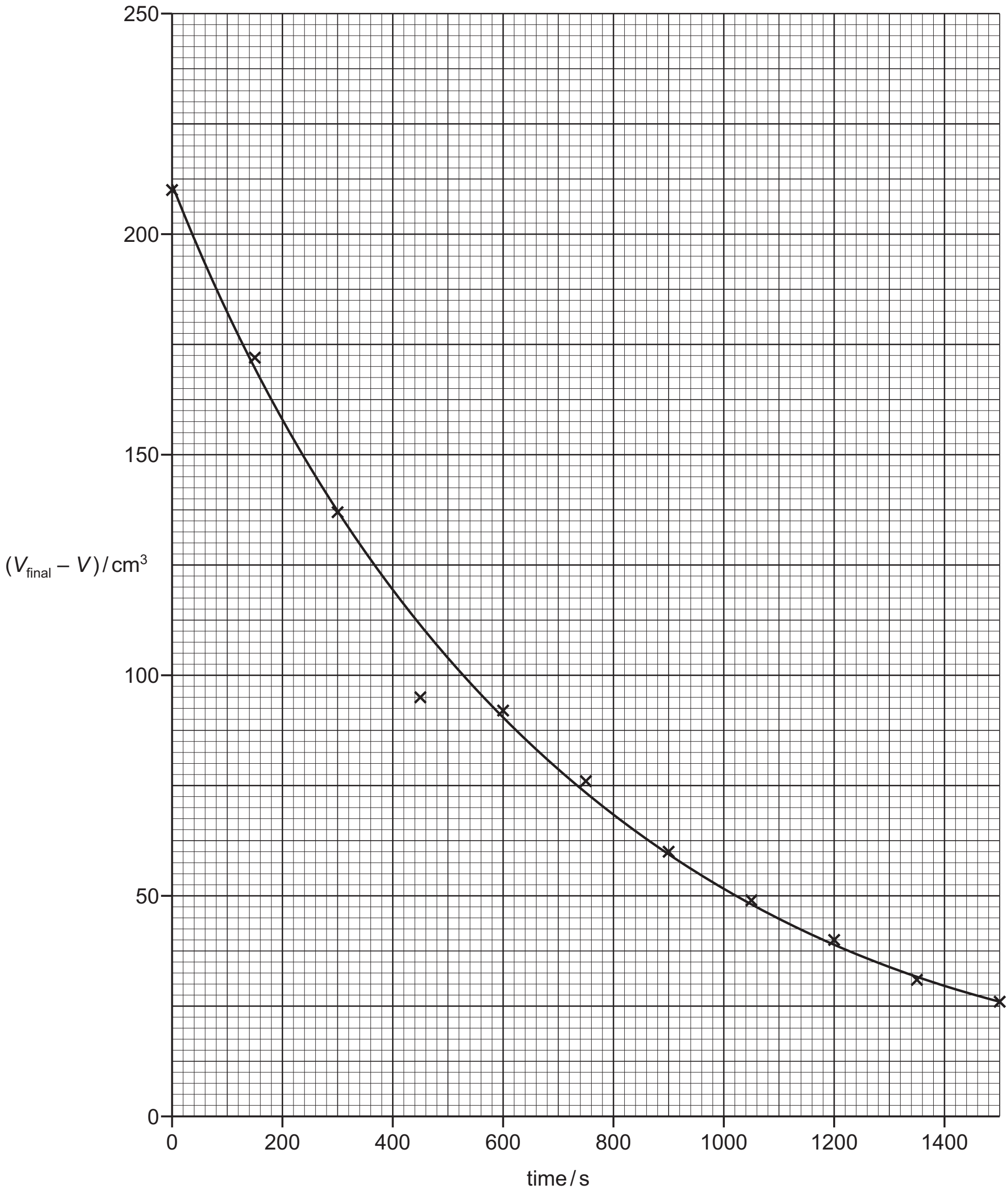
.....
[2]

(c) The graph below shows the results obtained from another benzenediazonium chloride hydrolysis reaction performed at a different temperature.



(i) The point at time = 450 s is considered to be anomalous.

Suggest what caused the anomaly.

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..... [1]

Question 2 continues on page 12.

(ii) The rate of reaction at different times can be calculated by drawing tangents to the best-fit line. The gradient of the tangent is equal to the rate of reaction, in $cm^3 s^{-1}$.

Use the graph in **(c)** to read the value of $(V_{final} - V)$ at time $t = 200$ s and write this value in the table below.

Draw a tangent to the curve at time $t = 200$ s. Use the tangent to determine the gradient at time $t = 200$ s.

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

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

gradient at 200 s = ... $cm^3 s^{-1}$

Use your gradient to complete the table.

time / s	$(V_{final} - V)$ / cm^3	rate of reaction / $cm^3 s^{-1}$
200		
500	104	–0.143
600	91	–0.127
900	59	–0.0867
1000	52	–0.0720
1400	30	–0.0417

[4]

(iii) The concentration of benzenediazonium chloride is directly proportional to $(V_{final} - V)$.

Use the data in the table in **(ii)** to calculate the order of reaction with respect to benzenediazonium chloride.

You must show your working.

[2]

[Total: 17]