Surname	StemUp Model Solution	Centre Number	Candidate Number
Other Names			2

GCE A LEVEL – NEW

A410U30-1

S17-A410U30-1

CHEMISTRY – A level component 3
Chemistry in Practice

TUESDAY, 27 JUNE 2017 – MORNING

1 hour 15 minutes

For Examiner's use only		
Question	**Maximum Mark**	**Mark Awarded**
1.	**11**	
2.	**17**	
3.	**6**	
4.	**12**	
5.	**4**	
6.	**10**	
Total	**60**	

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ADDITIONAL MATERIALS

In addition to this examination paper, you will need a:
- calculator;
- **Data Booklet** supplied by WJEC.

INSTRUCTIONS TO CANDIDATES

Use black ink or black ball-point pen.

Write your name, centre number and candidate number in the spaces at the top of this page.

Answer **all** questions in the spaces provided.

INFORMATION FOR CANDIDATES

The number of marks is given in brackets at the end of each question or part-question.

The maximum mark for this paper is 60.

Your answers must be relevant and must make full use of the information given to be awarded full marks for a question.

The assessment of the quality of extended response (QER) will take place in **Q.2***(c)*.

If you run out of space, use the additional page(s) at the back of the booklet, taking care to number the question(s) correctly.

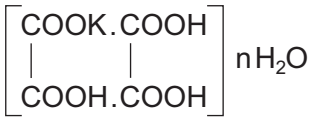
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Answer **all** *questions in the spaces provided.*

1. Hydrated potassium tetraoxalate has the following simplified structure.



It reacts with sodium hydroxide according to the following equation.

$$C_4H_3KO_8.nH_2O + 3NaOH \longrightarrow C_4Na_3KO_8.nH_2O + 3H_2O$$

A student carries out a two-part experiment to determine the value of n in hydrated potassium tetraoxalate.

(a) In part 1, the student weighs exactly 1.78 g of the solid and transfers all of it to a 250 cm^3 beaker. She adds 100 cm^3 of deionised water while stirring to ensure that it all dissolves. Describe, giving full practical details, how the volume is made up to **exactly** 250 cm^3. [3]

Pour the solution through a funnel into a 250 cm^3 volumetric (standard) flask.

Wash (rinse) the beaker, glass rod and funnel with deionised water and add all the washings to the volumetric flask.

Add deionised water until the bottom of the meniscus is exactly on the graduation mark (last few drops with a dropping pipette).

Stopper and invert (shake) the flask to mix thoroughly.

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(b) In part 2, the student titrates the potassium tetraoxalate solution against a standard solution of sodium hydroxide of concentration 0.100 mol dm^{-3} using a suitable indicator.

She obtains the following results using 25.0 cm^3 samples of the potassium tetraoxalate solution.

	Rough titration	Titration 1	Titration 2	Titration 3	Titration 4
Initial burette reading / cm^3	0.80	23.00	0.40	21.45	2.05
Final burette reading / cm^3	23.00	44.00	21.45	43.25	23.00
Titre volume / cm^3	22.20	21.00	21.05	21.80	20.95

Complete the table to show the volume of sodium hydroxide solution used in each titration and calculate an appropriate mean titre. [2]

Concordant titres: 21.00, 21.05 and 20.95 (rough and 21.80 ignored)

mean = (21.00 + 21.05 + 20.95) ÷ 3 = 21.00

Mean titre = ... 21.00 ..... cm^3

(c) Using the above information, calculate the relative molecular mass of $C_4H_3KO_8.nH_2O$ and hence the value of n. You **must** show clearly how you obtained your answer. [5]

$n(NaOH) = 21.00/1000 \times 0.100 = 2.10 \times 10^{-3}$ mol

$n(C_4H_3KO_8.nH_2O)$ in 25.0 $cm^3 = 2.10 \times 10^{-3} \div 3 = 7.00 \times 10^{-4}$ mol

n in 250 $cm^3 = 7.00 \times 10^{-4} \times 10 = 7.00 \times 10^{-3}$ mol

$M_r(C_4H_3KO_8.nH_2O) = 1.78 \div 7.00 \times 10^{-3} = 254.3$

$M_r(C_4H_3KO_8) = 4(12.0) + 3(1.0) + 39.1 + 8(16.0) = 218.1$

$18.0n = 254.3 - 218.1 = 36.2$

$n = 36.2 \div 18.0 = 2.01$, so $n = 2$

n = ... 2 .....

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(d) Her teacher carries out the same titration and obtains a titre of 21.10 cm^3. Calculate the maximum percentage error due to a burette with a maximum error of ± 0.05 cm^3 for each reading. [1]

two readings, so maximum error = 2 × 0.05 = 0.10 cm^3

% error = (0.10 ÷ 21.10) × 100 = 0.474 %

Maximum percentage error = ... *0.47* ..... %

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2. Metals **X** and **Y** are Group 2 metals. Each one could be Mg, Ca, Sr or Ba.

(a) Metal **X** appears not to react with cold water but reacts rapidly with steam.

Identify metal **X** and give the equation for its reaction with steam. [1]

Metal **X** magnesium (Mg)

$Mg(s) + H_2O(g) \rightarrow MgO(s) + H_2(g)$

(b) Metal **Y** reacts with cold water according to the following equation.

$$\mathbf{Y}(s) + 2H_2O(l) \longrightarrow \mathbf{Y}(OH)_2(aq) + H_2(g)$$

(i) When 2.27 g of metal **Y** are added to 600 cm^3 of water, the concentration of the metal hydroxide solution formed on complete reaction is 0.0431 mol dm^{-3}. [3]
Identify metal **Y**.

$n[Y(OH)_2] = 0.0431 \times 600/1000 = 0.02586$ mol

ratio $Y : Y(OH)_2$ is 1 : 1, so $n(Y) = 0.02586$ mol

$A_r(Y) = 2.27 \div 0.02586 = 87.8$, which is closest to Sr (87.6)

Metal **Y** strontium (Sr)

(ii) When 200 cm^3 of the 0.0431 mol dm^{-3} solution of $\mathbf{Y}(OH)_2$ formed in part (i) are added to excess sodium carbonate solution, $\mathbf{Y}CO_3$ is precipitated as a white solid and separated by filtration. The precipitate is washed with deionised water and heated at 100 °C until the mass of $\mathbf{Y}CO_3$ remains constant.

I. Give an equation, including **state symbols**, for the reaction of aqueous $\mathbf{Y}(OH)_2$ with aqueous sodium carbonate. [1]

$Sr(OH)_2(aq) + Na_2CO_3(aq) \rightarrow SrCO_3(s) + 2NaOH(aq)$

II. Calculate the maximum mass of $\mathbf{Y}CO_3$ formed, giving your answer to **three** significant figures. [3]

$n(SrCO_3) = n[Sr(OH)_2] = 0.0431 \times 200/1000 = 0.00862$ mol

$M_r(SrCO_3) = 87.6 + 12.0 + 3(16.0) = 147.6$

mass $= 0.00862 \times 147.6 = 1.272$ g $= 1.27$ g (3 sig figs)

Mass = 1.27 g

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(c) Carbonates of Group 2 decompose on heating according to the following general equation.

$$\mathbf{Z}CO_3(s) \longrightarrow \mathbf{Z}O(s) + CO_2(g)$$

Give the trend in thermal stability of the carbonates on going down Group 2 and describe an experiment to show how this pattern could be confirmed.

Your answer should include:

- a detailed description of the method used
- how to collect valid results, identifying the control variable(s)
- the expected observation(s) [6 QER]

The carbonates become more thermally stable going down Group 2 ($MgCO_3$ < $CaCO_3$ < $SrCO_3$ < $BaCO_3$), so more heat is needed to decompose them.

Method: put a known amount of carbonate in a hard-glass test tube, clamped, fitted with a bung and delivery tube dipping into a second tube of limewater. Heat strongly with a Bunsen flame and time how long the limewater takes to turn milky (cloudy) as CO_2 is given off. Repeat for each carbonate in turn.

Control variables (for valid results): the same number of moles of each carbonate (not the same mass), the same volume and concentration of limewater, the same distance from the flame and the same flame temperature (blue flame), and the same apparatus. Repeat and take a mean time.

Expected observations: the time taken for the limewater to turn milky increases going down the group (shortest for $MgCO_3$, longest for $BaCO_3$), which confirms the trend.

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(d) Give a precipitation reaction which can be used as a test for $Ba^{2+}(aq)$ ions, which would not give a positive result for $Mg^{2+}(aq)$ ions. Your answer should include the name of the reagent used, an equation for the precipitation reaction taking place and an explanation for your choice of reaction. [3]

Add a solution containing sulfate ions, e.g. dilute sulfuric acid (or sodium sulfate solution).

$Ba^{2+}(aq) + SO_4^{2-}(aq) \rightarrow BaSO_4(s)$

A white precipitate forms with Ba^{2+} but no precipitate forms with Mg^{2+}, because the solubility of the Group 2 sulfates decreases down the group: $BaSO_4$ is insoluble whereas $MgSO_4$ is soluble.

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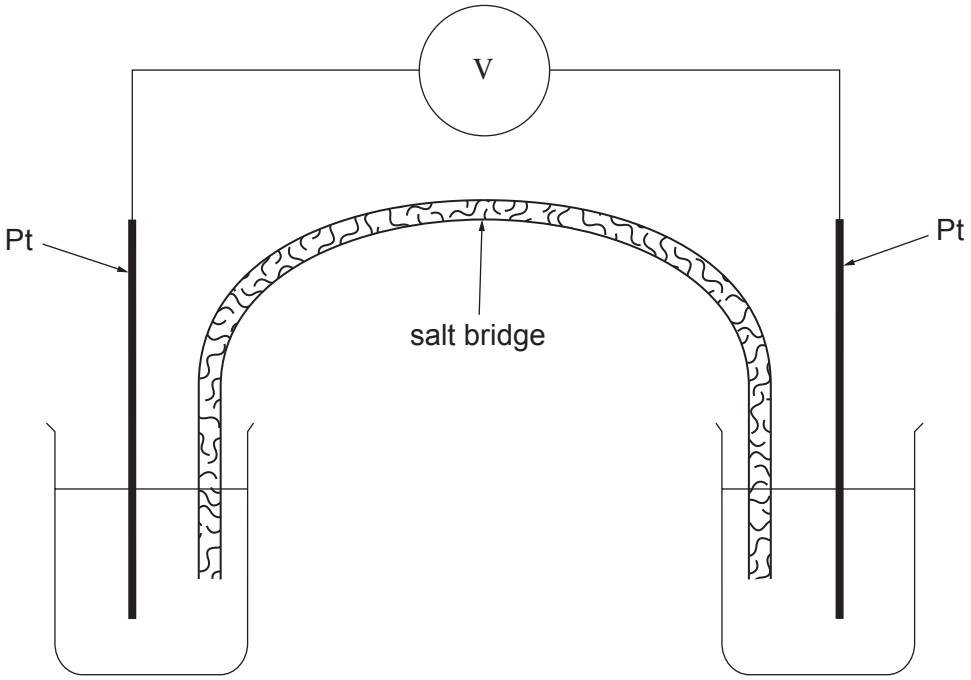
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3. A student set up an electrochemical cell made up of the two half-cells for which the half-equations are given below.

$$Fe^{3+}(aq) + e^- \longrightarrow Fe^{2+}(aq) \qquad E^\theta = +0.77\,V$$

$$MnO_4^-(aq) + 8H^+(aq) + 5e^- \longrightarrow Mn^{2+}(aq) + 4H_2O(l) \qquad E^\theta = +1.52\,V$$



$Fe^{3+}(aq) / Fe^{2+}(aq) \,|\, Pt$ $\qquad$ $MnO_4^-(aq), 8H^+(aq) / Mn^{2+}(aq), 4H_2O(l) \,|\, Pt$

Half-cell **A** $\qquad$ Half-cell **B**

(a) Suggest how the student made the salt bridge. [1]

A strip of filter paper soaked in saturated aqueous potassium nitrate (KNO_3) solution, dipping into both beakers.

(b) Write an equation for the overall cell reaction and calculate the standard cell potential for this cell. [2]

$MnO_4^- + 8H^+ + 5Fe^{2+} \rightarrow Mn^{2+} + 4H_2O + 5Fe^{3+}$

$E_{cell} = E(B) - E(A) = 1.52 - 0.77 = 0.75\ V$

Standard cell potential = 0.75 V

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(c) Describe **one** observation the student would have made in each half-cell after the cell had been connected for a period of time. [2]

Half-cell **A** *pale green solution turns more yellow / brown*

Half-cell **B** *purple colour fades (becomes paler / pale pink)*

(d) The student measured the cell potential and found that it was different from the value calculated in *(b)*. Suggest a reason for this. [1]

Conditions not standard, e.g. temperature not 298 K or solution concentrations not 1.00 mol dm^{-3}.

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4. The following method was used to determine the molecular and structural formula of a straight chain alkene **U** of general formula C_nH_{2n-2}. **U** reacts with bromine according to the following equation.

$$C_nH_{2n-2} + 2Br_2 \longrightarrow C_nH_{2n-2}Br_4$$

- Step 1: A 3.50 g sample of **U** was treated with 10.0 cm^3 of liquid bromine (an excess) at 20 °C, the reaction being carried out in a fume cupboard.
  (Density of bromine = 3.10 g cm^{-3} at 20 °C)
- Step 2: After the reaction between alkene **U** and bromine was complete, the unreacted bromine was treated with excess aqueous sodium iodide to form iodine.

$$2NaI(aq) + Br_2(l) \longrightarrow 2NaBr(aq) + I_2(aq)$$

- Step 3: The resulting solution was then made up to 250 cm^3 and the concentration of iodine present in solution determined by titration with a standard solution of sodium thiosulfate of concentration 1.05 mol dm^{-3}.

$$I_2(aq) + 2Na_2S_2O_3(aq) \longrightarrow 2NaI(aq) + Na_2S_4O_6(aq)$$

A 25.0 cm^3 sample of the iodine solution required 17.35 cm^3 of the sodium thiosulfate solution for complete reaction.

(a) Complete the risk assessment for step 1 given below. [1]

Hazard	Risk	Control measure
Bromine is very toxic and corrosive.	Bromine vapour is very toxic if inhaled; liquid causes severe burns if spilt on skin or eyes.	Reaction must be carried out in the fume cupboard. Wear eye protection and protective gloves.

(b) Use **all** the information provided to answer parts (i)-(iii).

(i) Calculate the total number of moles of bromine added in step 1. [2]

mass of Br_2 = density × volume = 3.10 × 10.0 = 31.0 g

$n(Br_2)$ = 31.0 ÷ 159.8 = 0.194 mol

$n(Br_2)$ added = ... 0.194 ..... mol

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(ii) Calculate the number of moles of bromine that did not react with the alkene and hence the number of moles of bromine that reacted. [4]

$n(Na_2S_2O_3) = 1.05 \times 17.35/1000 = 0.01822$ mol

$n(I_2)$ in 25.0 $cm^3 = 0.01822 \div 2 = 0.00911$ mol

$n(I_2)$ in 250 $cm^3 = 0.00911 \times 10 = 0.0911$ mol

$Br_2 : I_2$ is 1 : 1, so unreacted $n(Br_2) = 0.0911$ mol

$n(Br_2)$ reacted $= 0.194 - 0.0911 = 0.103$ mol

$n(Br_2)$ that reacted = ... 0.103 ..... mol

(iii) Determine the molecular formula of the alkene and hence suggest its structural formula and name. Show your reasoning. [5]

1 mol U reacts with 2 mol Br_2 (U contains two C=C bonds, a diene)

$n(U) = 0.103 \div 2 = 0.0515$ mol

$M_r(U) = 3.50 \div 0.0515 = 68.0$

C_nH_{2n-2}: $12.0n + 1.0(2n - 2) = 68.0$, so $14n = 70$ and $n = 5$

Molecular formula = C_5H_8

Structural formula

$CH_2=CH-CH_2-CH=CH_2$

Name ..... penta-1,4-diene .....

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5. Noradrenaline is a hormone that is produced naturally by the body. It is given by injection to treat a life-threatening drop in blood pressure.

A student was given a sample of noradrenaline for chemical testing in the laboratory. He carried out four tests as shown in the chart below.

Complete the chart.

- Describe the observations for tests 1 and 2.
- Identify the reagent(s) used in test 3.
- Draw the structure of the product formed in test 4. [4]

Test 1: Observation

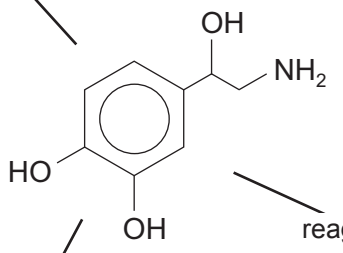
orange solution turns green

Test 2: Observation

purple colour (solution) forms

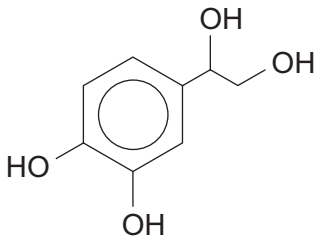
$Na_2Cr_2O_7(aq)$ / $H^+(aq)$
heat

neutral $FeCl_3(aq)$



noradrenaline

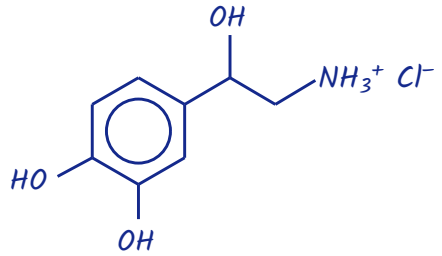
Test 3:
Bubbles of nitrogen gas produced. Major organic product formed is



reagent(s)

dilute HCl(aq)

Test 4: Structure of the product formed



Test 3: Reagent(s)

$NaNO_2$ and dilute HCl (HNO_2), below 10 °C

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6. The purpose of this experiment is to determine the activation energy (E_a) for the reaction of peroxodisulfate(VI) ions $S_2O_8^{2-}(aq)$ with iodide ions $I^-(aq)$ using a clock reaction.

Background

The equation for the reaction is as follows.

$$S_2O_8^{2-}(aq) + 2I^-(aq) \longrightarrow 2SO_4^{2-}(aq) + I_2(aq) \qquad \text{reaction 1}$$

A small, known volume of thiosulfate solution $S_2O_3^{2-}(aq)$ is added to the reaction mixture which also contains starch indicator. The thiosulfate reacts with the iodine mixture produced in reaction 1 according to the following equation.

$$2S_2O_3^{2-}(aq) + I_2(aq) \longrightarrow S_4O_6^{2-}(aq) + 2I^-(aq) \qquad \text{reaction 2}$$

At the exact instant that all the thiosulfate ions have reacted, free iodine is produced in the reaction solution and the blue-black colour of the iodine-starch complex is seen.

For this clock reaction then

$$\text{rate of reaction is} \propto \frac{1}{t} \qquad \text{where t = time for solution to turn blue-black}$$

Method

- Using a burette, 10.00 cm^3 of sodium peroxodisulfate(VI), $S_2O_8^{2-}(aq)$, of concentration 0.0200 mol dm^{-3} were added to a boiling tube and placed upright in a water bath at the required temperature.
- Using burettes, 5.00 cm^3 of potassium iodide solution, 5.00 cm^3 of sodium thiosulfate solution and 2.50 cm^3 of starch indicator were placed in a second boiling tube. This boiling tube was also placed upright in the same water bath.
- When the temperature of the two solutions reached the water bath temperature, the contents of the second boiling tube were poured into the first, the contents mixed rapidly and a stop clock started.
- The time taken for the blue-black colour of the starch-iodine complex to appear was recorded.
- This method was repeated at different temperatures.

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Results

Temperature / °C	Time (t) / s	Temperature (T) / K	1/T / K^{-1}	$\log_{10}(1/t)$
20	416	293	0.00341	–2·62
25	289	298	0.00336	–2·46
40	103	313	0.00319	–2·01
45	75	318	0.00315	–1·88
50	55	323	0.00310	–1.74
60	30	333	0.00300	–1·48

(a) Complete the results table. [2]

(b) State **one** factor that needs to remain constant in order to obtain valid results in this experiment. [1]

The concentration (and volume) of the iodide ions / potassium iodide solution.

(c) The Arrhenius equation can be rearranged as follows:

$$\log_{10}(1/t) = -\frac{E_a}{2.30RT} + \log_{10}A$$

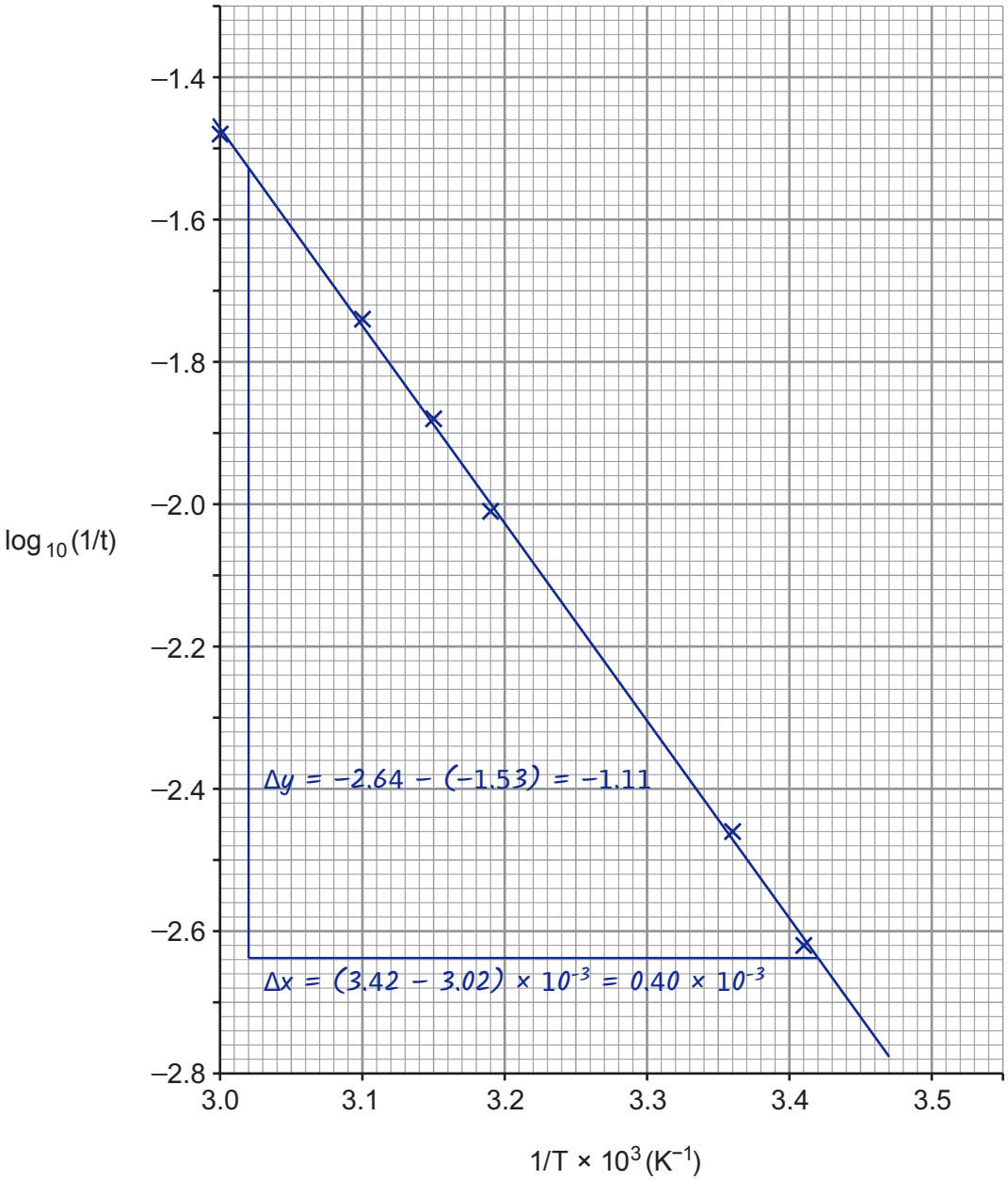
Plot $\log_{10}(1/t)$ against 1/T on the graph paper opposite and hence calculate the activation energy (E_a) for the peroxodisulfate(VI)-iodide reaction.

You **must** show clearly how you obtained your answer. [7]

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gradient = Δy ÷ Δx = −1.11 ÷ 0.40 × 10^{-3} = −2.78 × 10^{3} K (−2775 K)

gradient = $-E_a \div 2.30R$, so E_a = −gradient × 2.30R

E_a = 2775 × 2.30 × 8.31 = 53 000 J mol^{-1}

= 53.0 kJ mol^{-1}

Activation energy (E_a) = *53.0*

Unit *kJ mol^{-1}*

END OF PAPER

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