GCE A LEVEL – NEW

A410U30-1

S17-A410U30-1

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CHEMISTRY – A level component 3
Chemistry in Practice

TUESDAY, 27 JUNE 2017 – MORNING

1 hour 15 minutes

A410U301
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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.

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

1. Hydrated potassium tetraoxalate has the following simplified structure.

$$\left[\begin{array}{cc} COOK.COOH \\ | \quad\quad | \\ COOH.COOH \end{array} \right] nH_2O$$
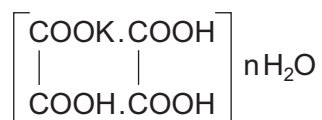
It reacts with sodium hydroxide according to the following equation.

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

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 cm³ beaker. She adds 100 cm³ 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 cm³. [3]

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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					

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

Mean titre = ... cm^3

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

n = ...

(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]

Maximum percentage error = ... %

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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** ....

....

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

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

(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**.

Metal **Y** ....

(ii) When 200 cm^3 of the 0.0431 mol dm^{-3} solution of **Y**(OH)$_2$ formed in part (i) are added to excess sodium carbonate solution, **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 **Y**CO$_3$ remains constant.

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

....

II. Calculate the maximum mass of **Y**CO$_3$ formed, giving your answer to **three** significant figures. [3]

Mass = ... g

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

$$ZCO_3(s) \longrightarrow ZO(s) + CO_2(g)$$

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]

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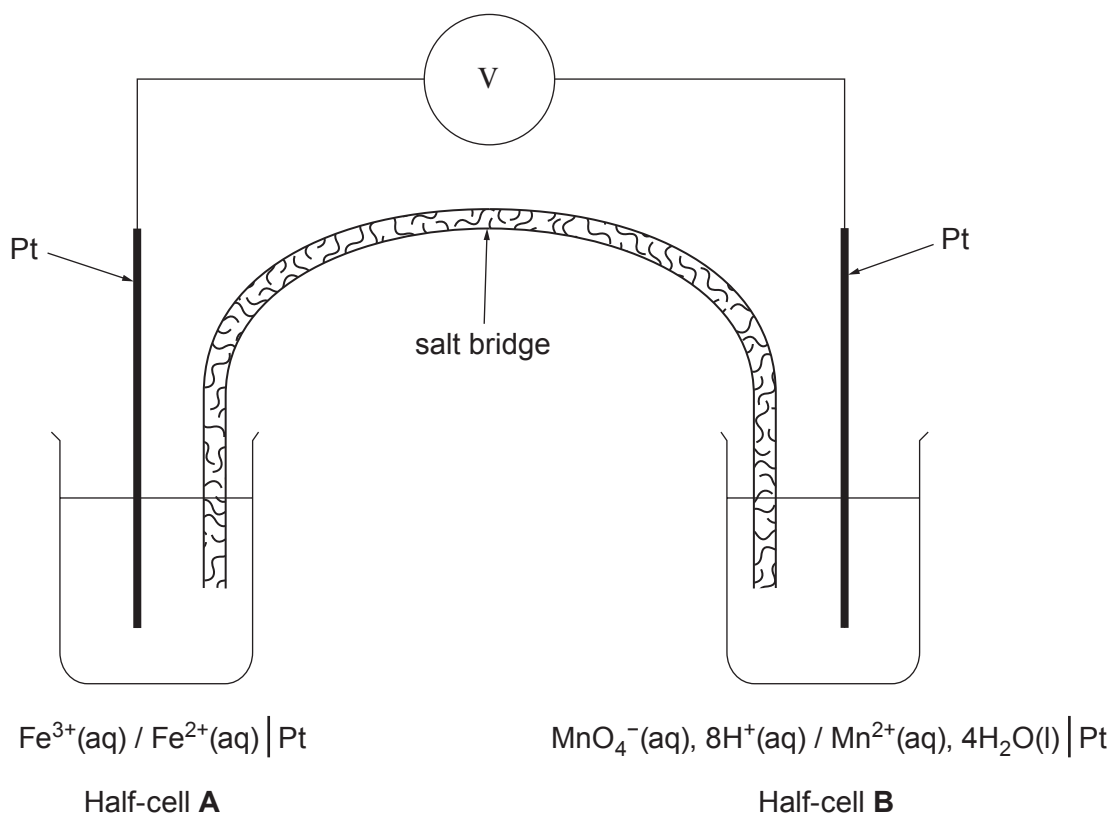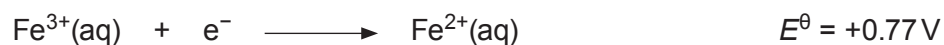
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3. A student set up an electrochemical cell made up of the two half-cells for which the half-equations are given below.

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

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

Fe^{3+}(aq) / Fe^{2+}(aq) | Pt

Half-cell **A**

MnO$_4^-$(aq), 8H$^+$(aq) / Mn^{2+}(aq), 4H$_2$O(l) | Pt

Half-cell **B**

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

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

....

Standard cell potential = ... V

(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** ....

Half-cell **B** ....

(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]

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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 cm³ 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 cm³ 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 cm³ sample of the iodine solution required 17.35 cm³ of the sodium thiosulfate solution for complete reaction.

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

Hazard	Risk	Control measure
		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]

n(Br₂) added = ... mol

(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(Br_2) that reacted = ... mol

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

Structural formula

Name ....

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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

Test 2: Observation

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

neutral $FeCl_3(aq)$

noradrenaline

OH

NH$_2$

HO

OH

reagent(s)

dilute HCl(aq)

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

OH

OH

HO

OH

Test 4: Structure of the product formed

Test 3: Reagent(s)

4

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.

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	....	0.00336	−2·46
40	103	313	0.00319	−2·01
45	75	318	0.00315	−1·88
50	55	323	0.00310	....
60	30	333	....	−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]
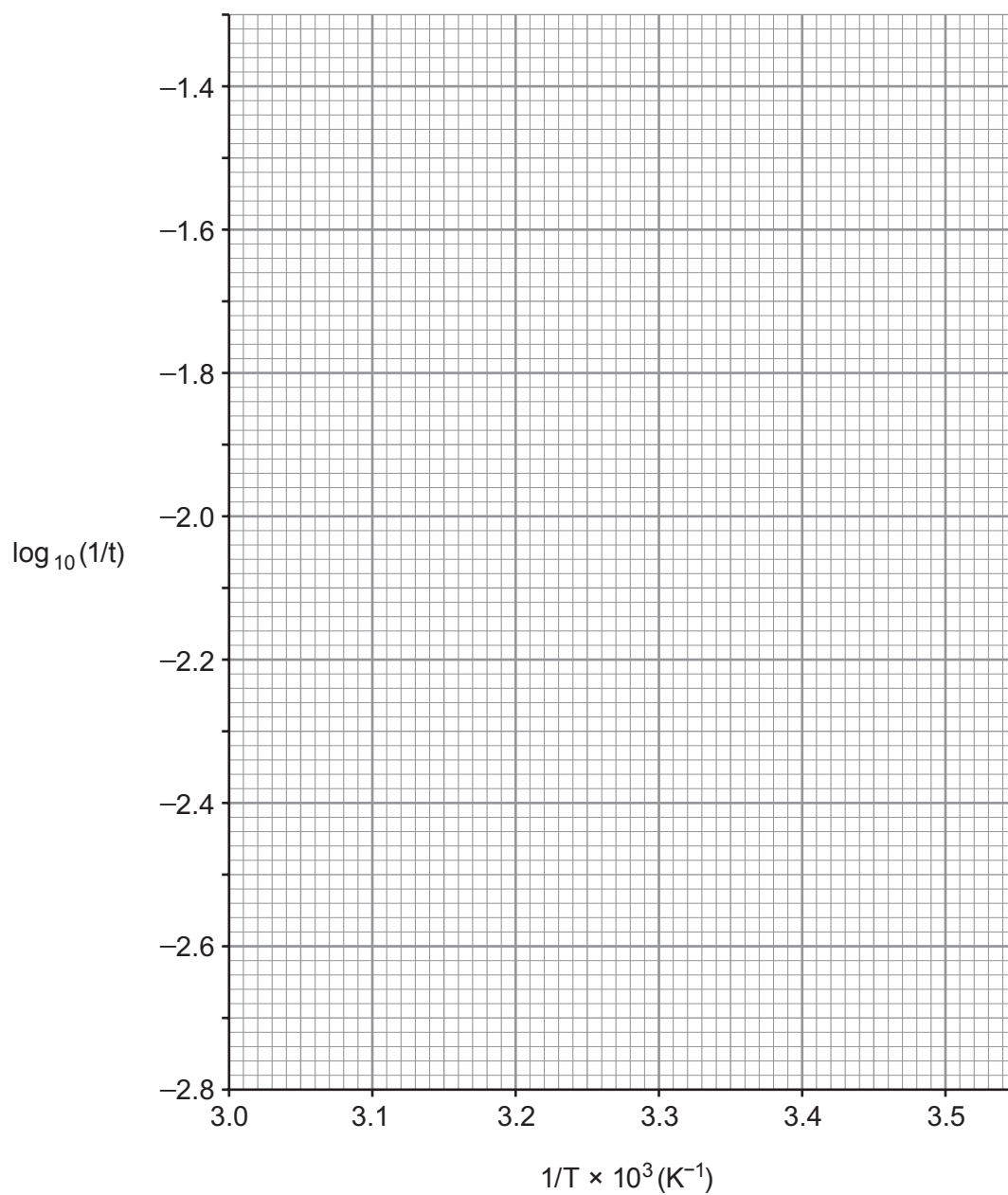
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(c) The Arrhenius equation can be rearranged as follows:

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

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]

Activation energy (E_a) = ...

Unit ....

END OF PAPER

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For continuation only.

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