OCR
Oxford Cambridge and RSA

A Level Chemistry A

H432/03 Unified chemistry

Practice paper – Set 1

Time allowed: 1 hour 30 minutes

You must have:
- the Data Sheet for Chemistry A

You may use:
- a scientific calculator
- a ruler (cm/mm)

First name										
Last name										
Centre number						**Candidate number**				

INSTRUCTIONS
- Use black ink. You may use an HB pencil for graphs and diagrams.
- Complete the boxes above with your name, centre number and candidate number.
- Answer **all** the questions.
- Write your answer to each question in the space provided. If additional space is required, use the lined page(s) at the end of this booklet. The question number(s) must be clearly shown.
- Do **not** write in the barcodes.

INFORMATION
- The total mark for this paper is **70**.
- The marks for each question are shown in brackets **[ ]**.
- Quality of extended responses will be assessed in questions marked with an asterisk (*).
- This document consists of **16** pages.

Answer **all** the questions.

1 This question is about numbers and patterns in chemistry.

(a) This part looks at number relationships. For calculations, show your working.

(i) What is the oxidation number of nitrogen in each species?

N_2O_4 …………. NO_3^- ………….. NH_4^+ …………..

[1]

(ii) What mass of $KMnO_4$ is needed to prepare a 250.0 cm^3 solution with a concentration of 0.200 mol dm^{-3} $KMnO_4$?

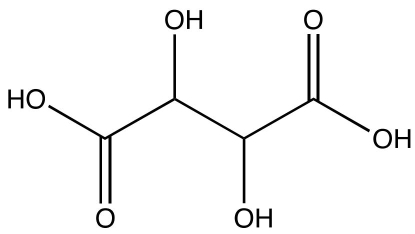
mass = ….……………………g **[2]**

(iii) What are the units of the rate constant for a reaction with an overall order of 3?

units = …...………………… **[1]**

(iv) How many molecules are in 38.25 g of tartaric acid?

Give your answer to an **appropriate** number of significant figures and in standard form.



tartaric acid

number of molecules = ... **[2]**

(b)* This question is about elements in Periods 3 – 4 of the periodic table.

The table shows the melting points of elements in Groups 14 – 17.

Phosphorus and sulfur exist as P_4 and S_8 molecules respectively.

	Group	**14**	**15**	**16**	**17**
Period 3	**Element**	Si	P	S	C*l*
	Melting point / °C	1414	44	115	–102
Period 4	**Element**	Ge	As	Se	Br
	Melting point / °C	938	817	221	–7

- Explain the trend in melting point from Si to C*l* across Period 3.
- Comment, with reasons, on the similarities and differences in the trends across Period 3 and Period 4.

Use the information in the table in your answer.

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.... **[6]**

2 This question is about redox reactions of transition elements.

(a) Hydrated copper(II) sulfate can crystallise with different numbers of water of crystallisation, *x*. Compound **A** has the formula $CuSO_4{\bullet}xH_2O$.

A student carries out an iodine–thiosulfate titration to find the value of *x* and the formula of Compound **A**. The method is outlined below.

Step 1 A weighed sample of **A** is dissolved in water and made up to 250.0 cm^3.

Step 2 A 25.00 cm^3 sample of this solution is pipetted into a conical flask, followed by an excess of KI(aq).

$$2Cu^{2+}(aq) + 4I^-(aq) \rightarrow 2CuI(s) + I_2(aq)$$

Step 3 The resulting mixture is titrated with 0.120 mol dm^{-3} $Na_2S_2O_3$(aq).

$$2S_2O_3^{2-}(aq) + I_2(aq) \rightarrow S_4O_6^{2-}(aq) + 2I^-(aq)$$

Mass readings
Mass of weighing bottle + **A** = 17.95 g
Mass of weighing bottle = 12.35 g

Titration readings

Titration	**Trial**	**1**	**2**	**3**
Final burette reading / cm^3	22.50	44.30	22.15	43.85
Initial burette reading / cm^3	0.00	22.50	0.00	22.15
Titre / cm^3				

Table 2.1

(i) Complete **Table 2.1** and calculate the mean titre that the student should use for analysing their results.

mean titre = ... cm^3 **[1]**

(ii) The uncertainty in each burette reading is ±0.05 cm^3.

Calculate the percentage uncertainty in the titre obtained from **titration 3**.
Give your answer to **two** decimal places.

percentage uncertainty = ... % **[1]**

(iii) In **step 2**, why is an excess of KI (aq) added?

....

....

.... **[1]**

(iv) As the end point of the titration is approached, the student adds a solution to accurately detect the end point.

State the solution and explain the colour change observed at the end point.

....

....

.... **[2]**

(v) Determine the formula of compound **A**.

Show your working.

formula of compound **A** = ... **[4]**

(b) A redox reaction takes place when copper metal is heated with concentrated sulfuric acid. A blue solution forms and 95.0 cm^3 of a colourless gas is collected, measured at RTP. The gas has a mass of 254 mg.

(i) Write the electron configuration, in terms of sub-shells, for a copper atom.

.... **[1]**

(ii) Suggest the identity of the colourless gas and write an equation for the reaction taking place.

State symbols are **not** required in the equation.

Show your working for calculations.

gas: ....

equation: ....
[4]

(c) A student carries out two experiments based on redox reactions of iron and chromium.

Use the standard electrode potentials below to help you answer the questions that follow.

$Fe^{2+}(aq) + 2e^-$	$\rightleftharpoons$	$Fe(s)$	$E^\ominus = -0.44$ V
$2H^+(aq) + 2e^-$	$\rightleftharpoons$	$H_2(g)$	$E^\ominus = 0.00$ V
$Fe^{3+}(aq) + e^-$	$\rightleftharpoons$	$Fe^{2+}(aq)$	$E^\ominus = +0.77$ V
$O_2(g) + 4H^+(aq) + 4e^-$	$\rightleftharpoons$	$2H_2O(l)$	$E^\ominus = +1.23$ V
$Cr_2O_7^{2-}(aq) + 14H^+(aq) + 6e^-$	$\rightleftharpoons$	$2Cr^{3+}(aq) + 7H_2O(l)$	$E^\ominus = +1.33$ V
$Cl_2(g) + 2e^-$	$\rightleftharpoons$	$2Cl^-(aq)$	$E^\ominus = +1.36$ V
$H_2O_2(aq) + 2H^+(aq) + 2e^-$	$\rightleftharpoons$	$2H_2O(l)$	$E^\ominus = +1.78$ V

For each experiment, identify the species causing the observations shown in bold text and write overall equations for any reactions taking place.

State symbols are **not** required in the equations.

(i) Experiment 1

1 The student adds iron filings to dilute hydrochloric acid.
A **green solution** forms and **gas bubbles** are seen.

2 The student bubbles air through the green solution.
The solution turns an **orange-brown colour**.

1: ....

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2: ....

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[3]

(ii) Experiment 2

The student heats a **green solution** of chromium(III) sulfate with dilute acid and hydrogen peroxide, H_2O_2.
The solution turns an **orange colour**.

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.... **[3]**

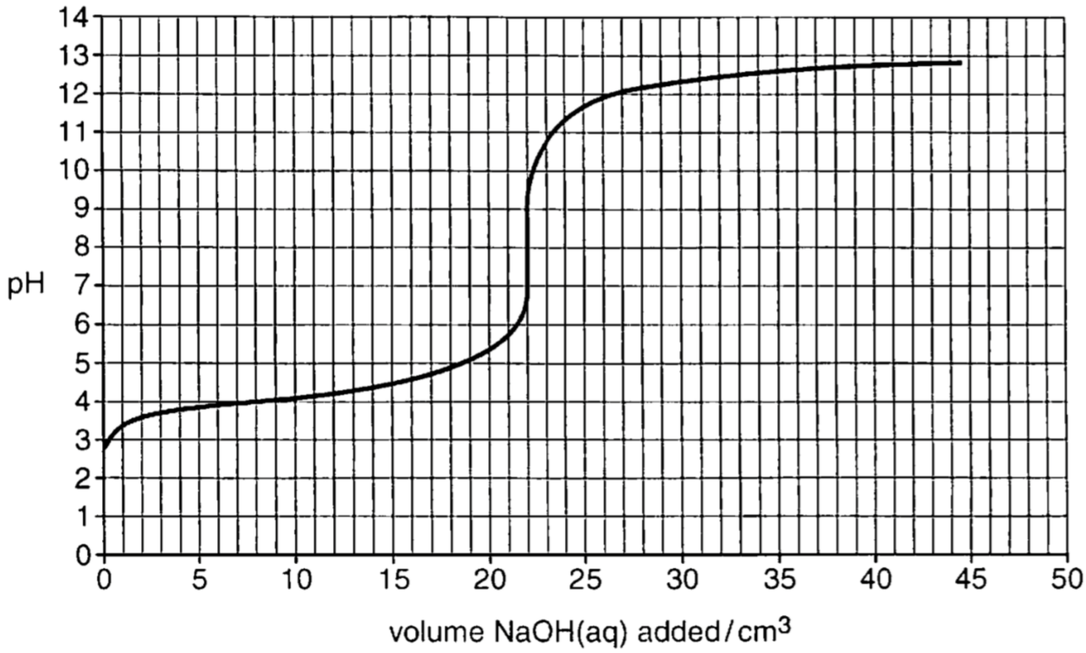
3 This question is about different weak acids.

(a) A student carries out a titration to determine the concentration of a solution of ethanoic acid.

The method is outlined below.

- A 25.0 cm^3 sample of $CH_3COOH(aq)$ is pipetted into a conical flask.
- The $CH_3COOH(aq)$ is titrated by adding 0.125 mol dm^{-3} NaOH from a burette.
- The pH of the solution is measured continuously, with stirring, as the NaOH(aq) is added.

The pH titration curve is shown below.



(i) How could the student measure the pH continuously as the NaOH(aq) is added?

....

.... **[1]**

(ii) Determine the unknown concentration, in mol dm^{-3}, of the $CH_3COOH(aq)$.

Show your working.

concentration of $CH_3COOH(aq)$ = ... mol dm^{-3} **[2]**

(b) The table shows the pH ranges of four indicators.

Indicator	congo red	methyl red	brilliant yellow	alizarin yellow R
pH range	3.0–5.0	4.4–6.2	6.6–7.8	10.1–12.0

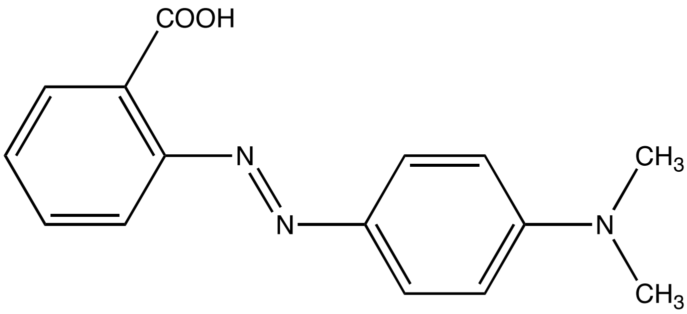
(i) Choose, with a reason, the indicator from the table that is most suitable for the student's titration in **(a)**.

....

.... **[1]**

(ii) An indicator is a weak acid, HA, which has a different colour from its conjugate base, A^-.

For methyl red, The HA form is red and the A^- form is yellow.
The structure of methyl red is shown below.



methyl red

Draw the structure of the conjugate base of methyl red and explain, in terms of equilibrium, the colours of methyl red at low pH, at high pH, and at the end point of a titration. You can use HA and A^- in your explanation.

explanation: ....

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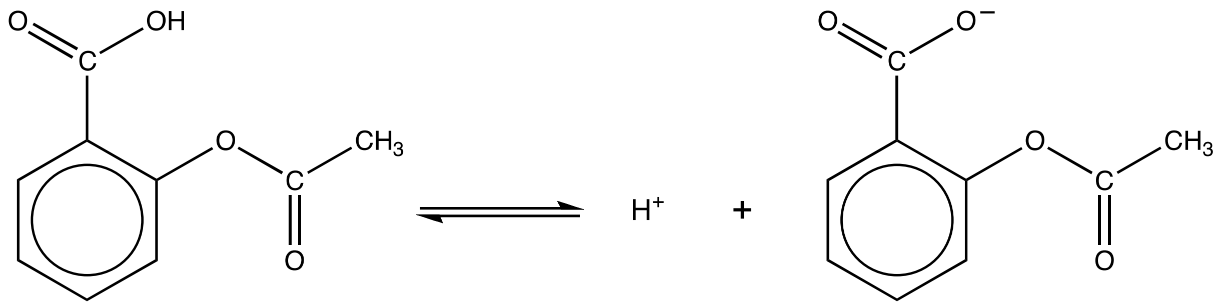
.... **[4]**

(c) Aspirin is a weak acid with a pK_a value of 3.40 and a solubility in water of 1.00×10^{-2} g cm^{-3} at body temperature (37 ºC).

The equation for the dissociation of aspirin in aqueous solution is shown below.



aspirin

(i) Calculate the pH of a saturated solution of aspirin in water at body temperature.

pH = ... **[4]**

(ii) 'Soluble aspirin' is usually sold as the sodium or calcium salt of aspirin.

Suggest why salts of aspirin are more soluble than aspirin in water.

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.... **[1]**

(iii) The stomach contains hydrochloric acid at a pH of about 1–3.

Explain why swallowing soluble aspirin may lead to irritation of the stomach lining.

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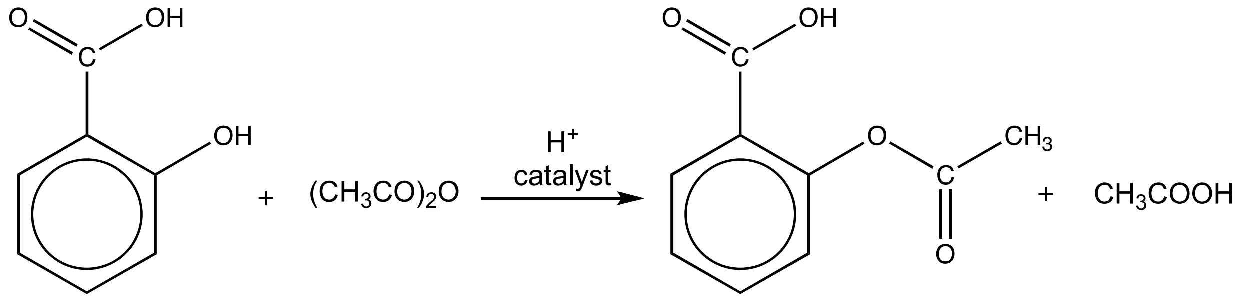
.... **[2]**

(d)* Aspirin can be made by refluxing 2-hydroxybenzoic acid with ethanoic anhydride, $(CH_3CO)_2O$, in the presence of a concentrated acid catalyst.



2-hydroxybenzoic acid **aspirin**

- Aspirin is much more soluble in hot water than in cold water.
- The percentage yield of aspirin from this method is 90.0%.

Outline a plan to prepare 8.10 g of pure aspirin.

In your answer, include the mass of 2-hydroxybenzoic acid needed and the purification steps from the hot reaction mixture.

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.... **[6]**

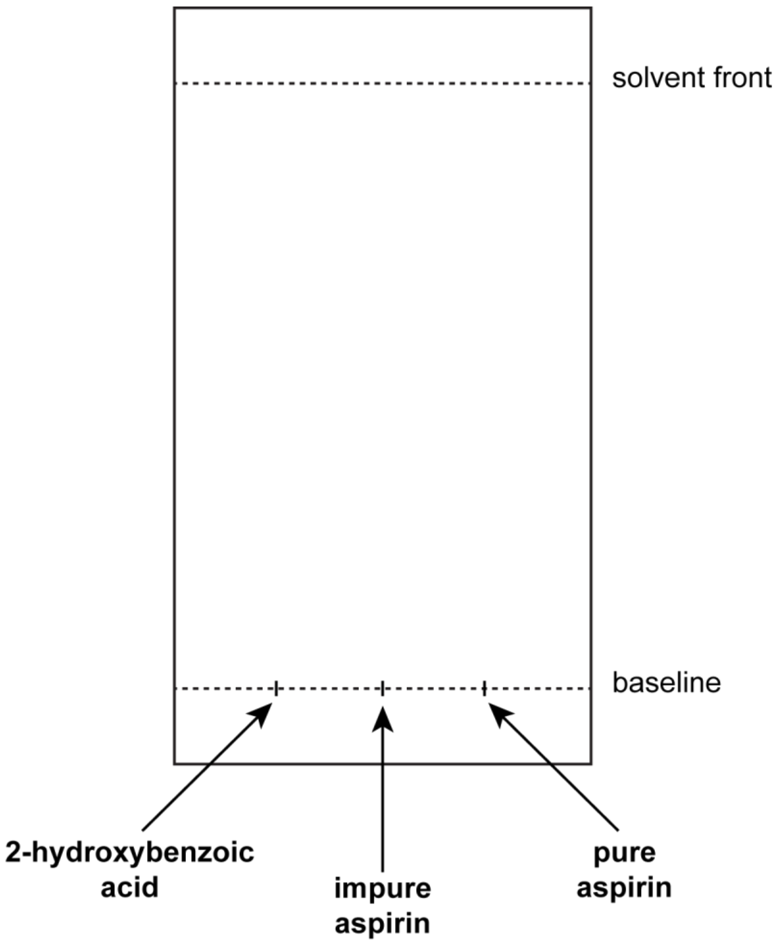
(e) The R_f values and melting point ranges of 2-hydroxybenzoic acid and pure aspirin are shown in the table.

Compound	R_f	**Melting point range/ °C**
2-Hydroxybenzoic acid	0.30	158–161
Pure aspirin	0.75	138–140

(i) A student analyses the purity of their impure aspirin by thin-layer chromatography (TLC).

From the results the student concludes that the impure aspirin is contaminated with a small amount of unreacted 2-hydroxybenzoic acid.

Draw spots on the chromatogram below to show how the student arrived at this conclusion.



[2]

(ii) Predict the melting point range of the impure aspirin.

.... **[1]**

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4 Ethers are a homologous series of organic compounds containing the R–O–R functional group.

The structures and names of two ethers are shown in **Fig. 4.1**.

methoxyethane **2-ethoxypropane**

Fig. 4.1

(a) Draw the **skeletal** formula of the ether, 2-ethoxy-3-methylbutane.

[1]

(b) Ethers can be prepared by nucleophilic substitution of haloalkanes with alkoxide ions, RO^-.

(i) Alkoxide ions can be prepared by reacting sodium with an alcohol. A gas is also formed.

Write an equation for the formation of methoxide ions from sodium and an alcohol.

.... **[1]**

(ii) Methoxyethane, shown in **Fig. 4.1**, can be prepared by reacting bromoethane, CH_3CH_2Br, with methoxide ions, CH_3O^-.

Suggest the mechanism for the nucleophilic substitution of CH_3CH_2Br with CH_3O^-.

Show curly arrows, charges, relevant dipoles, and products.

[3]

(iii) In this mechanism, explain how CH_3O^- ions have acted as a nucleophile.

State the type of bond fission that takes place.

....

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.... **[1]**

(c) 2-Ethoxypropane, shown in **Fig. 4.1**, is analysed by ^{1}H NMR spectroscopy.

Complete the table to predict the ^{1}H NMR spectrum of 2-ethoxypropane.
You may **not** need to use all the rows.

Chemical shift, δ/ppm	Relative peak area	Splitting pattern

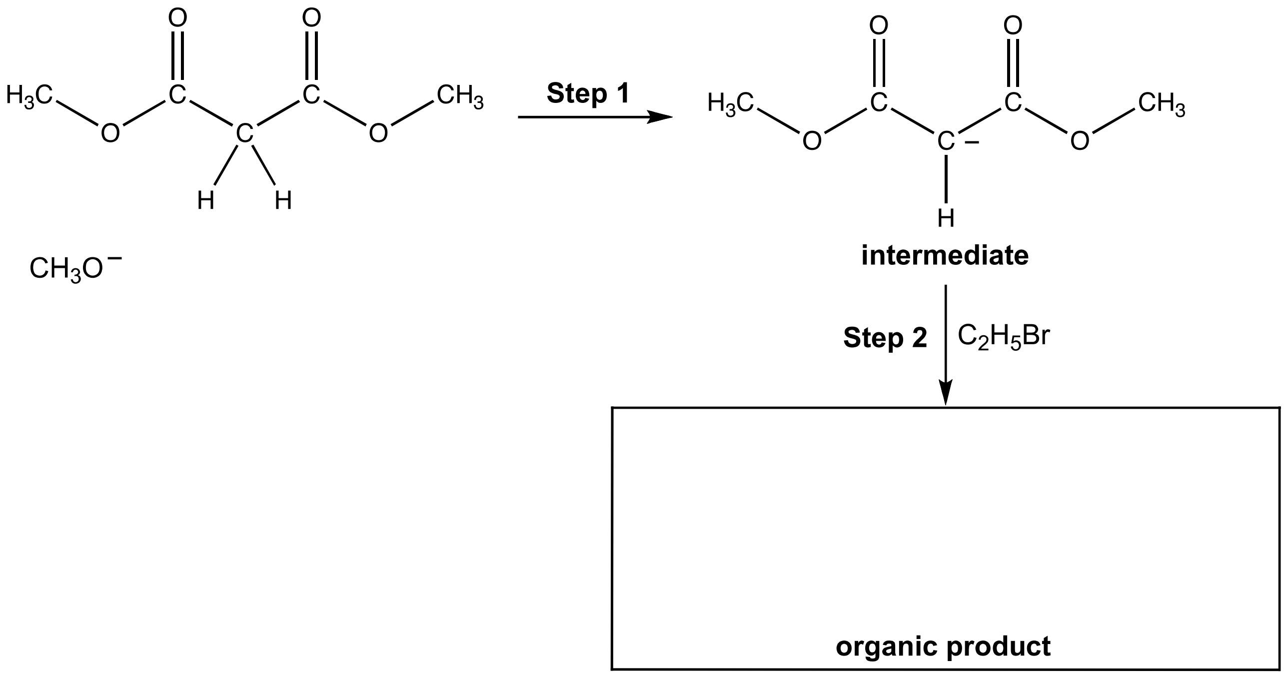
[4]

(d) In organic reactions, alkoxide ions can also act as a base.

The diagram below shows an incomplete mechanism for the reaction of a diester with methoxide ions, CH_3O^- (**Step 1**), followed by reaction of the intermediate with bromoethane (**Step 2**).

(i) For **Step 1**, add curly arrows to show how CH_3O^- reacts with the diester to form the intermediate.

In the box, draw the structure of the organic product formed in **Step 2**.



[3]

(ii) Explain how CH_3O^- ions have acted as a base in this mechanism.

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.... **[1]**

END OF QUESTION PAPER

ADDITIONAL ANSWER SPACE

If additional answer space is required, you should use the following lined page(s). The question number(s) must be clearly shown in the margin(s).