OCR
Oxford Cambridge and RSA

Tuesday 23 May 2023 – Morning

AS Level Chemistry B (Salters)

H033/02 Chemistry in depth

Time allowed: 1 hour 30 minutes

You must have:
- the Data Sheet for Chemistry B

You can use:
- a scientific or graphical calculator
- an HB pencil

Please write clearly in black ink. **Do not write in the barcodes.**

Centre number | | | | | | Candidate number | | | | |

First name(s) _____

Last name _____

INSTRUCTIONS
- Use black ink. You can use an HB pencil, but only for graphs and diagrams.
- Write your answer to each question in the space provided. If you need extra space use the lined pages at the end of this booklet. The question numbers must be clearly shown.
- Answer **all** the questions.
- Where appropriate, your answer should be supported with working. Marks might be given for using a correct method, even if your answer is wrong.

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

ADVICE
- Read each question carefully before you start your answer.

1 This question is about Group 2 compounds.

Group 2 hydroxides can be used to neutralise acidity in a variety of contexts. Magnesium hydroxide may be used to neutralise excess stomach acidity and calcium hydroxide may be used to neutralise acidity in soils.

The hydroxides are formed when the oxides react with water.

(a) Write an equation to show the ions formed when calcium oxide reacts with water.

[1]

(b) A student shakes a small amount of magnesium oxide in a test tube with water. A white suspension is formed.

The student then adds dilute hydrochloric acid, drop by drop with shaking, until no further changes are seen.

Describe how the **appearance** of the contents of the test tube changes during the addition of the acid.

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..... **[2]**

(c) Barium chloride solution is used to test for the presence of sulfate ions in solution.

Write an **ionic** equation for this test.

Include state symbols.

[2]

(d) A student is provided with a solid sample of an unknown Group 2 hydroxide, **X**$(OH)_2$.

The student describes how 250 cm^3 of a solution of this solid is made up in a volumetric flask.

Step 1 The mass of a weighing boat is measured and recorded.
Step 2 Solid is added to the boat and the new mass measured and recorded.
Step 3 The contents of the boat are tipped into a beaker.
Step 4 Deionised water is added.
Step 5 The mixture is stirred using a glass rod until all of the solid is dissolved.
Step 6 The glass rod is removed.
Step 7 The solution is poured through a funnel into the volumetric flask.
Step 8 The solution is made up to the mark with deionised water.
Step 9 The flask is stoppered and inverted several times.
Step 10 The concentration of the solution is calculated.

Describe **two** errors in this practical procedure made by the student and state the effect of each error on the concentration of the solution.

Error .....

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Effect on concentration .....

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Error .....

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Effect on concentration .....

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[4]

(e)* A student uses a titration to identify the unknown Group 2 metal **X** in a sample of **X**$(OH)_2$.

The student records the following data.

Mass of weighing boat + **X**$(OH)_2$ = 4.64 ± 0.005 g
Mass of weighing boat = 4.44 ± 0.005 g

The sample of **X**$(OH)_2$ is dissolved and made up to 250 cm^3 of solution in a volumetric flask.

The student titrates this solution with 0.0250 mol dm^{-3} HC*l*.

The student calculates correctly that the concentration of **X**$(OH)_2$ is 0.0106 mol dm^{-3}.

Use this data to calculate the M_r for **X**$(OH)_2$ and use this to identify the metal **X**.

Given that the percentage uncertainty is greatest for the mass, apply this percentage to the value of M_r when quoting your result. **[6]**

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Additional answer space if required

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2 Bromine can be extracted from sea water.

(a) Describe the appearance and physical state of bromine at room temperature.

..... **[1]**

(b) Sea water contains some bromide ions and these can be displaced as aqueous bromine by reaction with the more reactive halogen chlorine, as shown in **Equation 2.1**.

$2Br^-(aq) + Cl_2(aq) \rightarrow Br_2(aq) + 2Cl^-(aq)$ **Equation 2.1**

(i) Explain, in terms of electrons, why chlorine is more reactive than bromine.

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..... **[3]**

(ii) Identify the oxidising agent and reducing agent in **Equation 2.1**.

Oxidising agent .....

Reducing agent .....

[1]

(c) A student adds aqueous silver nitrate to an aqueous sodium halide. A precipitate forms but the student is unsure whether it is silver bromide or silver iodide.

Explain what the student can do to confirm the identity of the precipitate.

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..... **[2]**

(d) Silver bromide is light-sensitive and is used in photography.

Light causes the addition of electrons to the silver ions.

(i) Write a half-equation for the reaction that occurs in the presence of light.

[1]

(ii) Explain, in terms of electrons, whether silver ions are oxidised or reduced in this reaction.

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..... **[1]**

(e) The remaining silver bromide is removed by a developer, such as hydroquinone, $C_6H_4(OH)_2$.

This reacts with silver ions as shown:

.....Ag^+ + ...$C_6H_4(OH)_2$ $\rightarrow$ .....Ag + ...$C_6H_4O_2$ + ...H^+ **Equation 2.2**

Balance **Equation 2.2**. **[1]**

(f) A student adds concentrated phosphoric acid to an unknown solid sodium halide in a test tube. When the test tube is warmed, a colourless gas is given off.

When a red-hot inert wire is held in the mouth of the test tube, a purple colouration is seen around the hot wire.

Explain what is happening in the test tube and identify the sodium halide.

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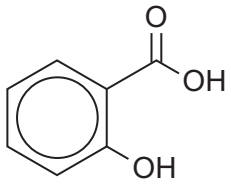
..... **[4]**

3 Aspirin, $CH_3COOC_6H_4COOH$, is a medicine that is made by an esterification reaction. It is conventionally made in the laboratory by refluxing a mixture of 2-hydroxybenzoic acid with ethanoic anhydride in the presence of a catalyst of concentrated sulfuric acid.

(a) The structure of 2-hydroxybenzoic acid is shown below.



2-hydroxybenzoic acid

Give the name of the –OH functional group attached directly to the benzene ring.

..... **[1]**

(b) The crude product from the esterification reaction requires purification.

Aspirin is soluble in hot water but insoluble in cold water. A student begins by adding a large volume of hot water to the crude product. The student then allows the hot solution to cool to room temperature. However, very little product recrystallises.

(i) Describe and explain how the student should modify this part of their technique in order to obtain more recrystallised product.

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..... **[2]**

(ii) Name a practical technique that the student could use to check the purity of a recrystallised product.

..... **[1]**

(c) The equation below shows the reaction for the preparation of aspirin.

$$HOC_6H_4COOH + (CH_3CO)_2O \rightarrow CH_3COOC_6H_4COOH + CH_3COOH$$

2-hydroxybenzoic acid	**ethanoic anhydride**	**aspirin**	**ethanoic acid**

A student prepares 3.06 g of aspirin having started with 3.45 g of 2-hydroxybenzoic acid and excess ethanoic anhydride.

(i) Calculate the percentage yield of aspirin in this preparation.

percentage yield = ... % **[3]**

(ii) Calculate the atom economy of this preparation of aspirin.

atom economy = ... % **[1]**

(d) Aromatic alcohols, such as phenylethanol, $C_6H_5CH_2CH_2OH$, have many of the properties of aliphatic alcohols.

(i) When $C_6H_5CH_2CH_2OH$ is oxidised with acidified potassium dichromate(VI), an aldehyde and a carboxylic acid are formed.

Name the practical technique that should be used to allow the formation of more aldehyde and less carboxylic acid.

..... **[1]**

(ii) Classify $C_6H_5CH_2CH_2OH$ as a primary, secondary or tertiary alcohol.

..... **[1]**

(iii) Give the structural formula of the ester formed when $C_6H_5CH_2CH_2OH$ reacts with ethanoic acid.

..... **[1]**

(iv) $C_6H_5CH_2CH_2OH$ undergoes a dehydration reaction when heated with concentrated sulfuric acid. However, phenylmethanol, $C_6H_5CH_2OH$, does **not** undergo this reaction.

- Use structural formulae to write an equation for the dehydration of $C_6H_5CH_2CH_2OH$.
- Name the **type** of reaction that occurs.
- Explain why this same reaction **cannot** occur in $C_6H_5CH_2OH$.

Equation

Type of reaction .....

Explanation .....

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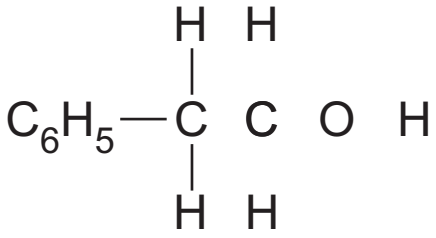
..... **[3]**

(e) Electron 'dot-and-cross' diagrams can be used to show the arrangements of electrons in molecules.

Add dots and crosses to the diagram of phenylethanol below (where bonds are not shown), and use this diagram to state and explain the C – O – H bond angle.



C – O – H bond angle = ...°

Explanation .....

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..... **[5]**

(f)* Three small aliphatic molecules are methanol, CH_3OH, methanal, HCHO, and methane, CH_4.

Describe and explain the intermolecular bonds present in each of the three compounds and use your explanations to deduce their relative boiling points.

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Additional answer space if required

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4 Ammonia, NH_3, is an important gas that is made industrially on a very large scale. It has a wide range of uses such as the production of synthetic fertilisers like ammonium nitrate.

The manufacture of ammonia occurs in the Haber process as shown in **Equation 4.1**.

$N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g)$ **Equation 4.1**

This reaction is an example of a dynamic equilibrium.

(a) A student says:

- When a reaction is in dynamic equilibrium, the forward and reverse reactions have stopped.
- This means that the concentrations of reactants and products remain constant.

Comment on the student's statements, correcting any errors.

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..... **[3]**

(b) For the equilibrium in **Equation 4.1**:

$$K_c = \frac{[NH_3]^2}{[N_2]\,[H_2]^3}$$

At a temperature of 472 K, this equilibrium constant has a numerical value of 0.105.

In an equilibrium mixture at this temperature, the concentration of N_2 is 4.02×10^{-2} mol dm^{-3} and the concentration of H_2 is 1.27×10^{-1} mol dm^{-3}.

Calculate the concentration of NH_3 in the mixture (in mol dm^{-3}) at the same temperature.

Give your answer to an **appropriate** number of significant figures.

concentration of NH_3 = ... mol dm^{-3} **[3]**

(c) Some of the ammonia produced in the Haber process is oxidised in the first step of a different process to make nitric acid, as shown in **Equation 4.2**.

$4NH_3(g) + 5O_2(g) \rightarrow 4NO(g) + 6H_2O(g)$ **Equation 4.2**

Calculate the minimum mass of oxygen (in kg) required to react with $4.8 \times 10^7\,cm^3$ of ammonia at 5.0×10^2 kPa and 900 K.

minimum mass of O_2 = ... kg **[4]**

(d) Ammonia can be converted into the fertiliser ammonium nitrate by reaction with nitric acid, as shown in **Equation 4.3**.

$NH_3 + HNO_3 \rightarrow NH_4NO_3$ **Equation 4.3**

Calculate the mass of ammonia (in kg) required to produce 1.00 tonne of ammonium nitrate.

mass of ammonia = ... kg **[2]**

(e) **Equation 4.1** is repeated below:

$N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g)$ **Equation 4.1**

The Haber process (**Equation 4.1**) uses an iron catalyst.

(i) What **type** of catalyst is iron in the Haber process?

..... **[1]**

(ii) Complete the following stages that describe the function of the iron in the Haber process.

Stage 1 nitrogen and hydrogen are adsorbed onto the surface of the iron

Stage 2 .....

Stage 3 .....

Stage 4 ammonia is desorbed from the surface of the iron

[1]

(f) Draw a labelled Boltzmann distribution curve for a reaction.

Mark the activation enthalpies when a catalyst is used and when it is not used.

[2]

END OF QUESTION PAPER

ADDITIONAL ANSWER SPACE

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