OCR
Oxford Cambridge and RSA

Monday 18 October 2021 – Morning

A Level Chemistry B (Salters)

H433/03 Practical skills in chemistry

Practical Insert

Time allowed: 1 hour 30 minutes

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INSTRUCTIONS
- Do **not** send this Insert for marking. Keep it in the centre or recycle it.

INFORMATION
- This document has **4** pages.

pH changes of solutions

A group of students record the pH of some solutions using a pH meter.
They then see what happens to the pH when they add water, acid and alkali to the solutions.

Requirements

The students are provided with the following, along with standard laboratory apparatus:

- stock solutions of the following:
  - propanoic acid 0.50 mol dm^{-3}
  - sodium propanoate 0.50 mol dm^{-3}
  - sodium hydroxide 0.050 mol dm^{-3}
  - hydrochloric acid 0.050 mol dm^{-3}.
- solid sodium propanoate
- distilled water
- pH meter
- electronic balance
- 100 cm^3 beakers.

Method

Set up three beakers, each containing 30 cm^3 of one of the solutions **A**, **B** and **C** shown below.

A 0.50 mol dm^{-3} propanoic acid solution, $C_2H_5COOH(aq)$
B 0.50 mol dm^{-3} sodium propanoate solution, $C_2H_5COONa(aq)$
C 0.50 mol dm^{-3} propanoic acid solution with 2.4 g of sodium propanoate dissolved in it.

- Gently place the pH meter into each solution in turn to measure the starting pH.
  Wash the pH meter with distilled water each time before placing it in the different solutions.
- Record the pH of each solution on addition of 20 cm^3 of water.
- Take 30 cm^3 of solution **A** and add 20 cm^3 of 0.050 mol dm^{-3} hydrochloric acid.
  Measure the pH.
- Take 30 cm^3 of solution **A** and add 20 cm^3 of 0.050 mol dm^{-3} sodium hydroxide.
  Measure the pH.
- Repeat the last two bullet points for solutions **B** and **C**.
- Record your results in the table.

The students' results are shown in the table on the next page.

Results table

	Starting pH	pH after the addition of water, acid or alkali		
Solution (volume used – 30 cm^3)		**+ 20 cm^3 water**	**+ 20 cm^3 0.050 mol dm^{-3} HCl(aq)**	**+ 20 cm^3 0.050 mol dm^{-3} NaOH(aq)**
A 0.50 mol dm^{-3} propanoic acid solution, $C_2H_5COOH(aq)$	2.5	2.7	1.7	3.7
B 0.50 mol dm^{-3} sodium propanoate solution, $C_2H_5COONa(aq)$	9.3	9.2	6.0	12.5
C 0.50 mol dm^{-3} solution of propanoic acid with 2.4 g of sodium propanoate dissolved in it.	5.1	5.1	5.1	5.2

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Time allowed: 1 hour 30 minutes

You must have:
- the Practical Insert (inside this document)
- the Data Sheet for Chemistry B

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

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H433/03

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.

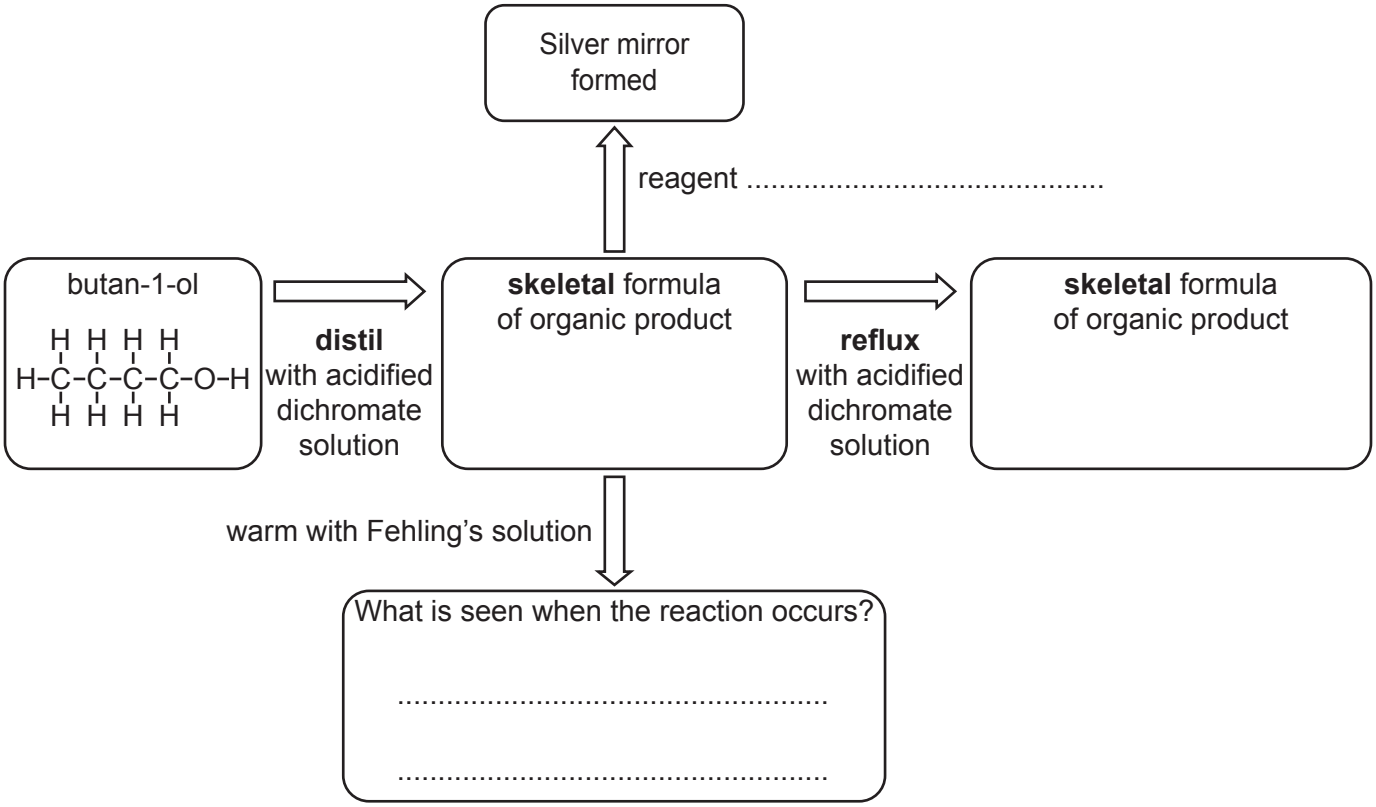
INFORMATION
- The total mark for this paper is **60**.
- The marks for each question are shown in brackets **[ ]**.
- Quality of extended response will be assessed in questions marked with an asterisk (*).
- This document has **16** pages.

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

Answer **all** the questions.

1 Alcohols are useful intermediates and react to give a variety of products.
For example, butan-1-ol can be oxidised to other useful products as shown below.

(a) Complete the flow diagram by writing on the dotted lines and drawing skeletal formulae in the empty boxes.



[4]

(b) Butan-2-ol is an isomer of butan-1-ol.

Alcohols can be categorised as primary, secondary or tertiary.
Which is the correct category for butan-2-ol?

Explain your answer.

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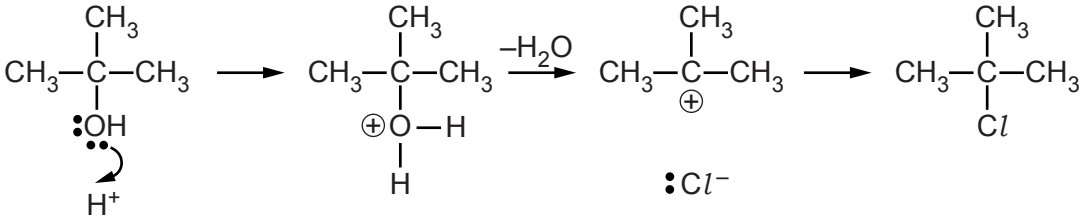
..... **[2]**

(c) Alcohols can also undergo substitution reactions.
The following sequence shows an incomplete mechanism for the reaction between $(CH_3)_3COH$ and concentrated hydrochloric acid.



The 'curly arrow' shows the movement of a pair of electrons.
Complete this mechanism by drawing **two** more curly arrows in appropriate places. **[2]**

(d)* A student prepares a pure sample of $(CH_3)_3CCl$ by the reaction from **(c)**:

$(CH_3)_3COH + HCl \longrightarrow (CH_3)_3CCl + H_2O$

The preparation involves two parts.

Part A The student shakes about 10 cm^3 of the alcohol with 20 cm^3 of concentrated hydrochloric acid in a stoppered conical flask. The reaction occurs quickly at room temperature.

Part B The student then separates the layers formed, removes the acid and dries and purifies the organic product.

The student uses data as shown in the table below.

Compound	Does it mix with water?	Density / g cm^{-3}
$(CH_3)_3COH$	yes	0.78
$(CH_3)_3CCl$	no	0.85

Describe and explain the student's procedure in **part B**. **[6]**

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Additional answer space if required.

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2 Our bodies contain many proteins, including enzymes.
These proteins have individual molecular shapes.

(a) A protein can be described in terms of its primary, secondary and tertiary structure.
Explain the terms primary, secondary and tertiary in this context.

Primary .....

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Secondary .....

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Tertiary .....

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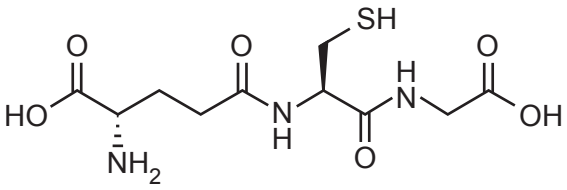
[3]

(b) Peptides and proteins are condensation polymers formed from amino acid monomers.

The tripeptide glutathione is an antioxidant found in the body.

The skeletal structure of glutathione is:



(i) Explain the significance of the dashed line and the wedge shown on the structure.

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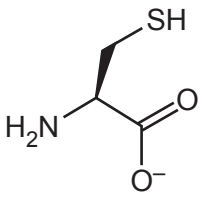
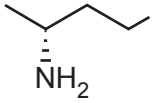
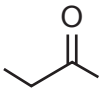
(ii) There are **three** organic products from the **alkaline** hydrolysis of glutathione.

The skeletal structure of one of the organic products is shown below.



Complete the skeletal structures of the other two organic products in the boxes below.





[2]

(c) Many medicinal molecules, including glutathione, show stereoisomerism and interact with active sites on protein molecules in the body.

(i) Salbutamol and salmeterol are medicines used in the treatment of asthma.

They contain the same **pharmacophore**.

Explain the term **pharmacophore**.

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

(ii) Salbutamol and salmeterol are both chiral molecules and have enantiomers.

The structure of salbutamol can be represented as shown below.

$R_1CH(OH)R_2$

Use this representation to draw appropriate structural diagrams of salbutamol to explain the terms **chiral** and **enantiomer**.

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(iii) One of the enantiomers of salbutamol is nearly seventy times more effective at treating asthma than the other.

Suggest why this is the case.

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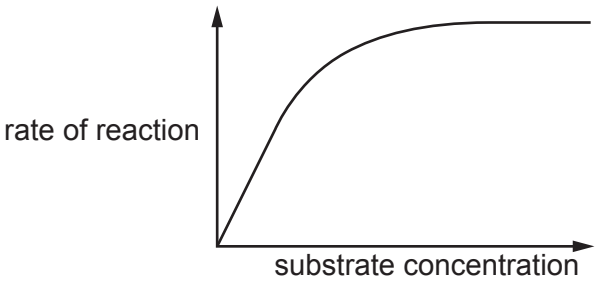
(d) An investigation into the effect of changing substrate concentration on the rate of an enzyme catalysed reaction gave the following graphical results.



A student suggested that the graph showed that the reaction is first order with respect to the substrate.

Comment on the student's suggestion, using the shape of the graph to help explain your reasoning.

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3 Brine is a solution of mainly sodium chloride in water. There is also some iodine present as the iodide ion, I^-.
I^- ions are oxidised to I_2 commercially using chlorine.

(a) Some students investigate this process.
They react aqueous chlorine with aqueous potassium iodide.
They then shake the resulting solution with an equal volume of cyclohexane.
They see a brown layer and a purple layer.

(i) Write an ionic equation for the reaction.

[1]

(ii) Identify the coloured layers.

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

(b) One way to determine the amount of iodine in brine is to react the brine with an excess of aqueous Cu^{2+} ions.
This produces molecular iodine along with a precipitate of copper(I) iodide.

$2Cu^{2+}(aq) + 4I^-(aq) \rightarrow 2CuI(s) + I_2(aq)$ **Equation 3.1**

The iodine, I_2, produced can then be quantitatively measured using titration with aqueous thiosulfate ions, $S_2O_3^{2-}$.

$I_2(aq) + 2S_2O_3^{2-}(aq) \rightarrow 2I^-(aq) + S_4O_6^{2-}(aq)$ **Equation 3.2**

(i) Analysis of 25.0 cm^3 of a sample of brine by this method gave an average titre of 14.20 cm^3 of 1.00×10^{-3} mol dm^{-3} aqueous $S_2O_3^{2-}$.

Calculate the concentration of iodine in the brine in **mg dm^{-3}**.

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

concentration of iodine = ... mg dm^{-3} **[4]**

(ii) The reaction in **Equation 3.2** is a redox reaction.

$I_2(aq) + 2S_2O_3^{2-}(aq) \rightarrow 2I^-(aq) + S_4O_6^{2-}(aq)$ **Equation 3.2**

The thiosulfate ion, $S_2O_3^{2-}$, is oxidised by the iodine.
Use oxidation numbers to explain why this is an oxidation.

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

(c) The element iodine is much less soluble in water than potassium iodide, KI.

State the structures of iodine and potassium iodide.

Suggest why potassium iodide is more water-soluble than iodine.

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

4 This question refers to the **Practical Insert** that is provided as an insert to this paper.

For propanoic acid, C_2H_5COOH, $K_a = 1.3 \times 10^{-5}\,mol\,dm^{-3}$.

(a) (i) Investigate, by **calculation**, whether the starting pH of 2.5 recorded for the propanoic acid solution is the expected value.

[2]

(ii) A student says that the pH of propanoic acid with the added HCl(aq) is the same as if the 20 cm^3 of 0.05 $mol\,dm^{-3}$ HCl(aq) had been diluted with 30 cm^3 water.

Carry out a calculation to see whether this is so.

[2]

(b) Explain, using an appropriate equation, why the sodium propanoate solution is alkaline.

In your explanation you should identify the species behaving as a base and identify its conjugate acid.

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(c) Investigate, by **calculation**, whether the starting pH of 5.1 recorded for the solution of propanoic acid with dissolved sodium propanoate is the expected value.

[4]

(d)* One of the solutions in the table is a buffer solution.

Choose the buffer solution, giving evidence from the students' results, and explain, with equations, why this solution acts as a buffer solution while the other two do not.

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Additional answer space if required.

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(e) Buffer solutions can also be prepared using weak bases in solution such as amines, RNH_2.

Explain, in terms of their electronic structure, why amines behave as bases in aqueous solution. You should draw a labelled diagram of the amine structure to help explain your answer.

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..... **[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).