Monday 19 October 2020 – 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.

Mechanisms of hydrolysis reactions of haloalkanes

A group of students investigated whether the structure of a haloalkane affects the rate equation and mechanism for a substitution reaction.

They studied the rate of hydrolysis of the tertiary haloalkane, 2-bromo-2-methylpropane and the primary haloalkane, 1-bromobutane using hydroxide ions.

Method 1: The hydrolysis of 2-bromo-2-methylpropane, $CH_3C(CH_3)BrCH_3$

Equal moles of 2-bromo-2-methylpropane and sodium hydroxide in solution were mixed at room temperature. At the start of the reaction a sample was withdrawn and the reaction in the sample was quenched (slowed down or stopped). The concentration of hydroxide in the sample was determined by titration. The sampling and quenching procedure was repeated every 5 minutes as the reaction proceeded. The results are shown in **Table 4.1**.

Time / min	**$[OH^-] \times 10^{-3}$ / mol dm^{-3}**
0	50.0
5	30.0
10	19.5
15	12.0
20	9.0
25	5.0
30	4.5

Table 4.1

Method 2: The hydrolysis of 1-bromobutane, $CH_3CH_2CH_2CH_2Br$

The initial concentrations of 1-bromobutane and sodium hydroxide were changed as in **Table 4.2**. The initial rate of reaction was measured for each mixture.

Mixture number	**$[C_4H_9Br] \times 10^{-1}$ / mol dm^{-3}**	**$[OH^-] \times 10^{-1}$ / mol dm^{-3}**	**Initial rate / mol dm^{-3} s^{-1}**
1	0.25	0.10	3.2×10^{-6}
2	0.50	0.10	6.5×10^{-6}
3	0.50	0.50	3.3×10^{-5}

Table 4.2

Research by the students found there were two possible mechanisms for this type of substitution reaction.

Either: $C_4H_9Br + OH^- \rightarrow C_4H_9OH + Br^-$ (**mechanism A**)

Or: $C_4H_9Br \rightleftharpoons C_4H_9^+ + Br^-$ **followed by** $C_4H_9^+ + OH^- \rightarrow C_4H_9OH$ (**mechanism B**)

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Oxford Cambridge and RSA

Monday 19 October 2020 – Morning

A Level Chemistry B (Salters)

H433/03 Practical skills in chemistry

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

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 A student is investigating the properties of some s-block metals and their compounds.

(a) Complete the electronic configuration, using sub-shells, of an **atom** of sodium and the magnesium **ion** in magnesium carbonate.

sodium **atom** $1s^2$ ....

magnesium **ion** $1s^2$ .... **[2]**

(b)* Group 2 carbonates react with hydrochloric acid as shown in **equation 1.1**.

$MCO_3(s) + 2HCl(aq) \rightarrow MCl_2(aq) + CO_2(g) + H_2O(l)$ **Equation 1.1**

A student investigates whether there is a trend in Group 2 of the rate of this reaction.
The student uses a method involving collection of the carbon dioxide given off.

Describe a suitable procedure that the student should follow and how the results can be interpreted. **[6]**

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Additional answer space if required

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(c) The student is given a sample of an unknown Group 2 carbonate MCO_3.

The student is told to heat the sample to constant mass and use the results to identify the Group 2 carbonate.

(i) Explain the term 'heat to constant mass'.

....

.... **[1]**

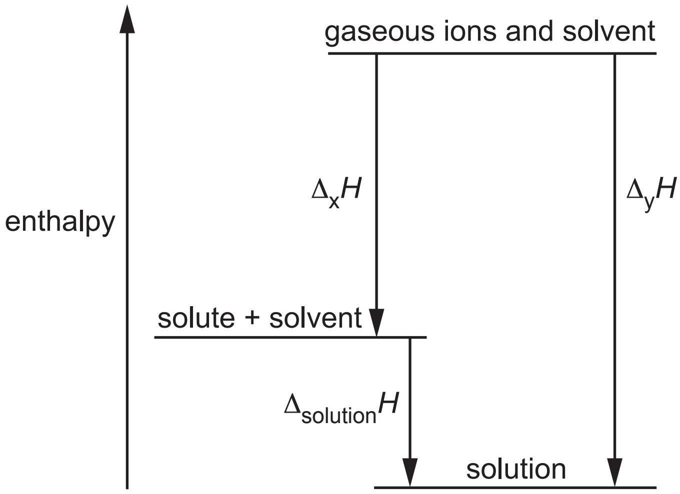
(ii) 4.00 g of a metal carbonate MCO_3 gives 1.91 g of MO on heating to constant mass.

Identify metal M in MCO_3 showing a suitable calculation.

metal M is .... **[3]**

(d) Some Group 2 salts are soluble in water.

The enthalpy cycle below shows the key enthalpy changes involved in dissolving ionic solids in water.



Name the enthalpy change(s) represented by $\Delta_x \boldsymbol{H}$ and $\Delta_y \boldsymbol{H}$.

$\Delta_x \boldsymbol{H}$ ....

$\Delta_y \boldsymbol{H}$ ....

[2]

(e) The enthalpy change of hydration is less negative for barium ions than for calcium ions.

Student **A** says this is because barium is more reactive than calcium.
Student **B** says it is due to the differences between Ca^{2+} and Ba^{2+} ions.

Comment on the students' statements giving the correct chemistry.

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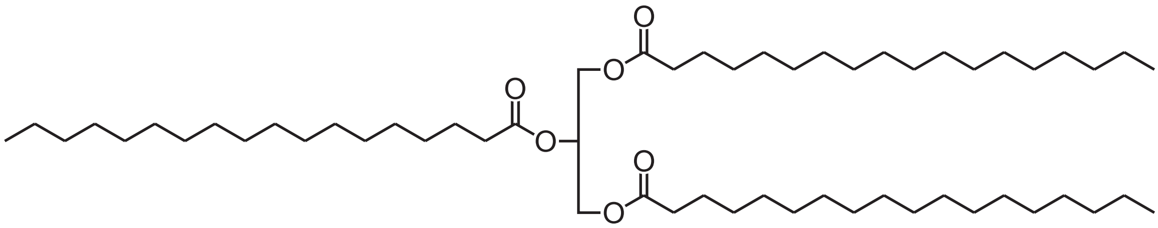
.... **[4]**

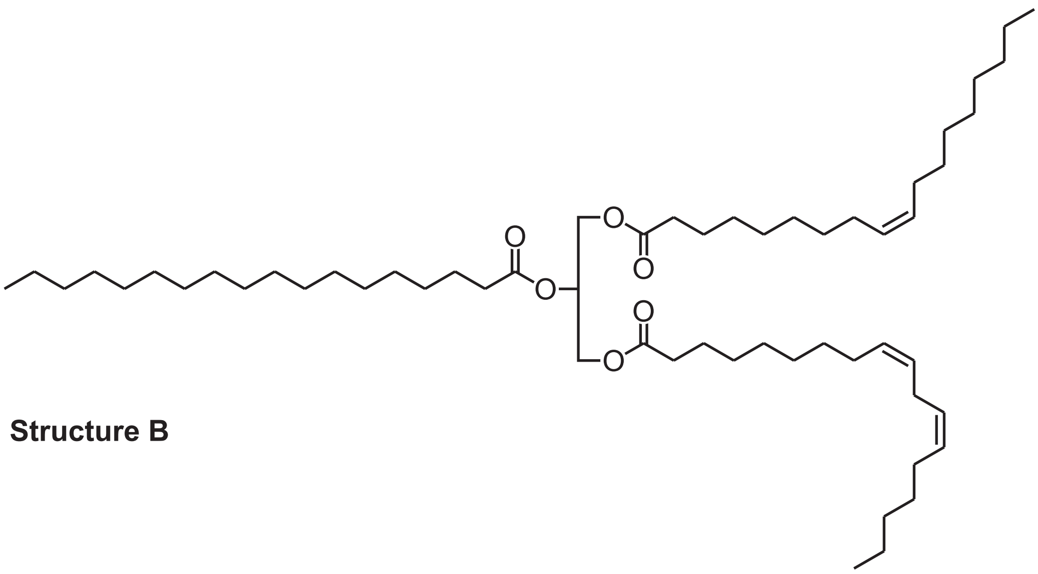
2 Fats and oils are essential to living systems.

Most fats and oils are triesters formed from the reaction of propane-1,2,3-triol (glycerol) with long chain carboxylic acids (fatty acids).

(a) Two triesters **A** and **B** are shown below.



Structure A



Structure B

(i) Structure **B** is described as a 'cis' unsaturated oil.

Explain the meanings of 'cis' and 'unsaturated'.

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.... **[2]**

(ii) State the types of intermolecular bonds between molecules of both structures **and** describe where in the molecules they occur.

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.... **[2]**

(iii) Suggest why Structure **A** is more likely to be a solid at room temperature than Structure **B**.

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.... **[3]**

(b) Methyl benzoate is a liquid at room temperature and has a boiling point of 200 °C.

The steps in a procedure for preparing and purifying the simple ester, methyl benzoate, are shown in the flow chart.

1. Add an excess of methanol to 8.0 g of benzoic acid followed by a few drops of concentrated sulfuric acid.
2. → Cool the mixture, pour into a separating funnel and add a similar volume of cyclohexane.
3. → Vigorously shake the mixture, allow to settle. Run off the lower layer.
4. → Wash the cyclohexane layer left in the separating funnel with sodium carbonate solution.
5. → Run off the cyclohexane layer into a conical flask and allow to stand over solid anhydrous sodium sulfate and then filter.
6. → Distil the cyclohexane layer collecting the distillate above 190 °C.

Give the reasons for the following experimental procedures in the flow chart:

(i) adding cyclohexane

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.... **[1]**

(ii) adding sodium carbonate solution

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.... **[1]**

(iii) standing the cyclohexane layer over solid anhydrous sodium sulfate

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.... **[1]**

(iv) collecting the distillate above 190 °C

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.... **[1]**

(c) A student followed the procedure in the flow chart and obtained 5.46 g of methyl benzoate.

The equation for the preparation is:

$C_6H_5COOH + CH_3OH \rightarrow C_6H_5COOCH_3 + H_2O$

benzoic acid methanol methyl benzoate

Calculate the percentage yield of methyl benzoate.

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

percentage yield = ... % **[4]**

3 The two isomers of propanol, C_3H_7OH can be used as fuels.

(a) A student measures the enthalpy change of combustion of propan-1-ol, C_3H_7OH. The apparatus used is shown in **Fig. 3.1**.

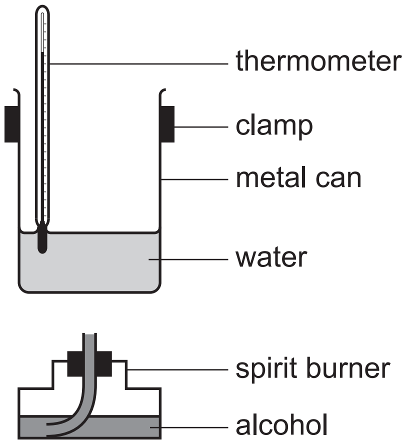

Fig. 3.1

The student's results are shown in **Table 3.1**.

Mass of spirit burner + propan-1-ol	43.11 g
Mass of spirit burner + propan-1-ol after burning	42.92 g
Initial temperature of water	19.7 °C
Final temperature of water	31.2 °C
Mass of water in metal can	100 g

Table 3.1

Use the results in **Table 3.1** to calculate a value for the enthalpy change of combustion of propan-1-ol, $\Delta_c H$, in kJ mol^{-1}.

Enthalpy change of combustion of propan-1-ol, $\Delta_c H$ = ... kJ mol^{-1} **[3]**

(b) The data book value for the enthalpy change of combustion of propan-1-ol is $-2021\,kJ\,mol^{-1}$.

(i) One reason for the difference is heat loss to the surroundings.

Suggest **two** other reasons for the difference between the experimental value and the data book value.

1 ....

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2 ....

.... **[2]**

(ii) Describe **one** addition to the apparatus in **Fig. 3.1** that would improve the accuracy of the experimental value for the enthalpy change of combustion.

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.... **[1]**

(c) The data book value for the enthalpy change of combustion of propan-2-ol is very similar to that of propan-1-ol.

(i) Write out the **full** structural formulae of the **two** compounds.

propan-1-ol **propan-2-ol**

[1]

(ii) Explain why the enthalpy change of combustion values are exothermic and very similar. Use your answer to **(c)(i)** and the idea of average bond enthalpies in your answer.

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.... **[3]**

4 **This question refers to the Practical Insert that is found inside this document.**

(a)* **Method 1** uses a series of titrations to determine the concentration of hydroxide ions at specific time intervals. The reaction is complete in about 30 minutes.

Suggest the procedure needed for the titrations using **Method 1**, starting from when the reagents are mixed. Include how to calculate the data shown in **Table 4.1**. **[6]**

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Additional answer space if required

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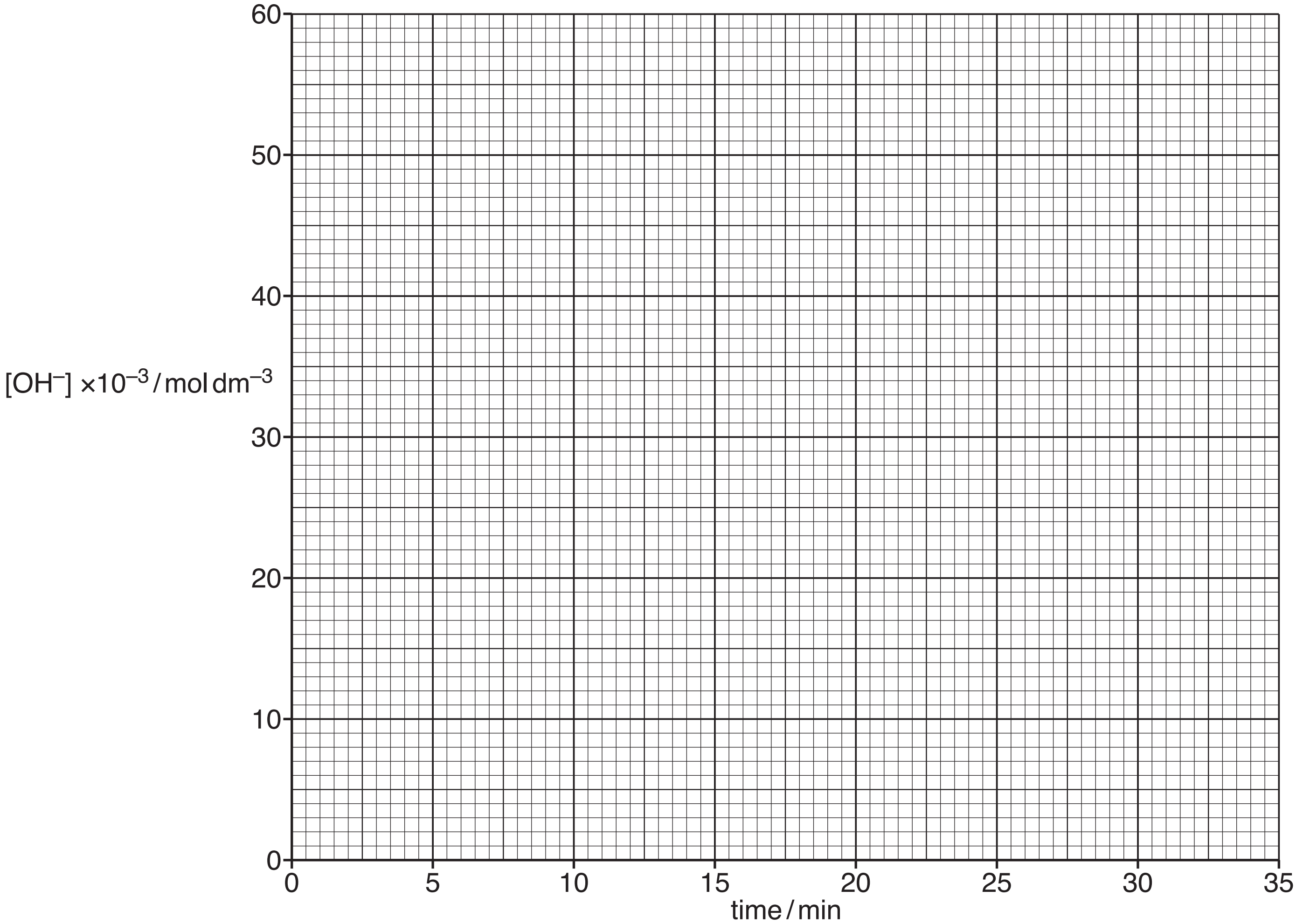
(b) (i) Using the data from **Table 4.1** in the Practical Insert, plot a graph on the grid below.

Include a curve of best fit.



[2]

(ii) Use your graph to calculate the time taken for the concentration of hydroxide ions to fall from 40×10^{-3} to 20×10^{-3} and from 20×10^{-3} to 10×10^{-3} mol dm^{-3}.

Show your working on the graph.

Time taken to fall from 40×10^{-3} to 20×10^{-3} mol dm^{-3} = ... min

Time taken to fall from 20×10^{-3} to 10×10^{-3} mol dm^{-3} = ... min **[2]**

(iii) Explain how the graph shows that the **overall** order of the reaction is first order.

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.... **[2]**

(iv) A student is told that the reaction followed using **Method 1** goes by **mechanism B**.

The student says that the first reaction in **mechanism B** must be the rate-determining step. This accounts for the overall first order of the reaction.

Comment on the student's statement.

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.... **[2]**

(c) (i) Use the data in **Table 4.2** to determine the order of reaction with respect to 1-bromobutane and hydroxide ions in **Method 2**.

Give your reasoning.

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.... **[2]**

(ii) Complete the rate equation for the reaction in part **(c)(i)**.

Rate = **[1]**

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).