OCR
Oxford Cambridge and RSA

AS Level Chemistry B (Salters)

H033/02 Chemistry in depth

Friday 25 May 2018 – Morning

Time allowed: 1 hour 30 minutes

You must have:
- the Data Sheet for Chemistry B (Salters) (sent with general stationery)

You may use:
- a scientific calculator

First name	
Last name	

Centre number						Candidate number				

INSTRUCTIONS
- Use black ink. HB pencil may be used for graphs and diagrams only.
- 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.

DC (NH/CT) 153078/5

Answer **all** the questions.

1 Chemists have arranged the elements into a Periodic Table which allows them to make predictions about the behaviour of the elements and their compounds.

(a) Many properties, such as first ionisation enthalpy, show a gradual change across a **period**.

(i) Write an equation representing the first ionisation enthalpy of sodium.

Show state symbols.

[2]

(ii) Explain the **general** increase in first ionisation enthalpy across Period 3 (sodium to argon).

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.... **[2]**

(b) Elements in a **group** often show similar properties.

The Group 2 element calcium reacts with water to produce a solution of calcium hydroxide and bubbles of hydrogen gas.

Predict a chemical equation for the reaction of radium, Ra, with water.
Include state symbols.

[1]

(c) Mendeleev first proposed his Periodic Table in 1869. He left gaps for elements which he predicted would be discovered later.

One such element was in a gap immediately below silicon and he called it ‘eka-silicon’.

Predict the formula of the oxide of eka-silicon, giving a reason.
Use **X** as the symbol for eka-silicon.

Formula ....

Reason ....

.... **[2]**

(d)* A student is asked to identify a solid Group 2 compound, **A**.

The student carries out the following tests.

1. A very small amount of the solid is added to 2 cm depth of water in a test tube. Compound **A** partly dissolves. A couple of drops of universal indicator are added which show a pH of 11.

2. The student carries out a titration to calculate the M_r of the compound and hence identify the Group 2 element present.

   0.092 g of compound **A** is dissolved in water and made up to 250 cm^3. 25.0 cm^3 samples of this solution are titrated with 0.0100 mol dm^{-3} hydrochloric acid giving a mean titre of 24.80 cm^3.

Identify compound **A**, giving reasons in full for your choice and including a chemical equation for the reaction in the titration.

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.... **[6]**

(e) Calculate the volume of gas (in cm^3 at RTP) produced when 0.493 g of barium carbonate, $BaCO_3$, is reacted with an excess of hydrochloric acid. (M_r of $BaCO_3$ = 197.2)

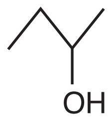
$$BaCO_3 + 2HCl \rightarrow BaCl_2 + CO_2 + H_2O$$

volume of gas = ... cm^3 **[1]**

2 Bioethanol is a well-known biofuel. Biobutanol is another biofuel and can be used in some combustion engines. Biobutanol can be produced in the UK from sugar beet.

(a) Butanol has the molecular formula, $C_4H_{10}O$. There are four structural isomers with this formula that contain the –OH functional group.

Complete the table below to show **one** other structural isomer of $C_4H_{10}O$ that contains an –OH group.

skeletal formula			
name	butan-1-ol	butan-2-ol	

[2]

(b) Explain why the combustion of butan-1-ol is exothermic, using ideas about bond-breaking and bond-making.
You do not need to list the specific bonds broken and made.

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.... **[2]**

(c) One disadvantage of butan-1-ol as a fuel is that it requires a higher oxygen to fuel ratio for complete combustion when compared to ethanol.

Write equations to show that butan-1-ol requires a higher oxygen to fuel ratio than ethanol for complete combustion.

combustion of butan-1-ol:

combustion of ethanol:

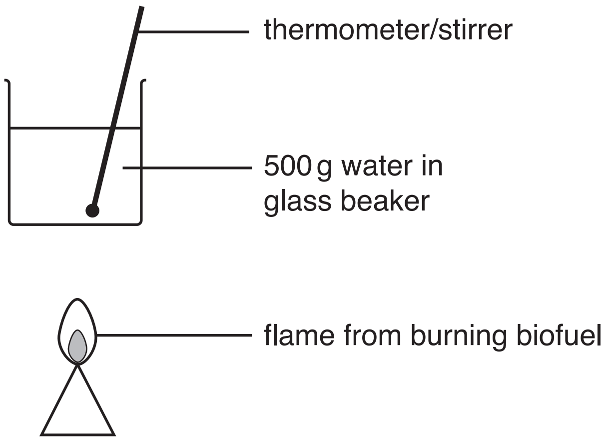
[1]

(d) In a simple laboratory experiment, the combustion of 1.00 g of a biofuel compound raised the temperature of 500 g of water by 16.0 °C.

Calculate a value for the enthalpy change of combustion of the biofuel compound.
(M_r of the biofuel compound = 214)

$\Delta_c H$ = ... $kJ\,mol^{-1}$ **[3]**

(e) The laboratory set-up used to obtain the data in part **(d)** is shown below.



This set-up can be modified to improve the accuracy of the value for the enthalpy change.

Suggest and explain **one** simple modification that could improve the accuracy.

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.... **[1]**

(f) Another alcohol that is used in some fuels is methanol, CH_3OH.

An equation for the complete combustion of methanol is shown below.

$$CH_3OH(g) + 1\frac{1}{2}O_2(g) \rightarrow CO_2(g) + 2H_2O(g) \qquad \Delta_c H = -677\ kJ\ mol^{-1}$$

Use this information and the data in the table below to calculate a value for the bond enthalpy of the C–O bond.

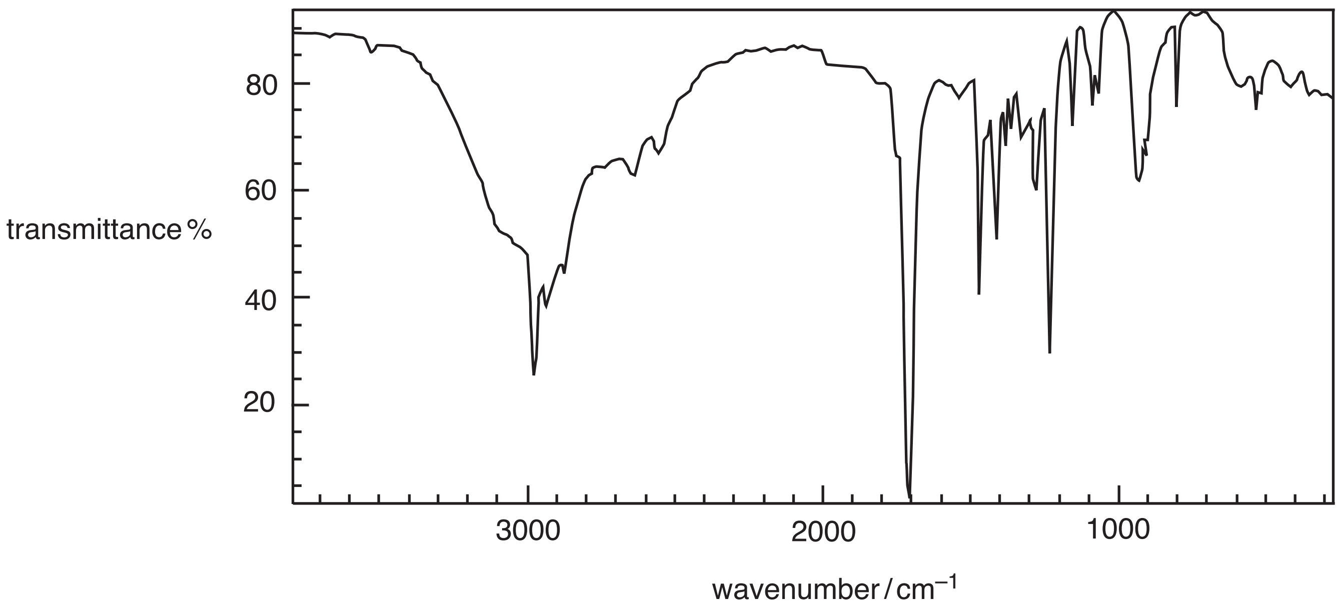
Bond	**Bond enthalpy / kJ mol^{-1}**
C–H	+413
O=O	+498
O–H	+464
C=O	+805

bond enthalpy of C–O bond = ... kJ mol^{-1} **[3]**

(g)* Apart from being used in fuels, alcohols are also important in the preparation of other organic chemicals.

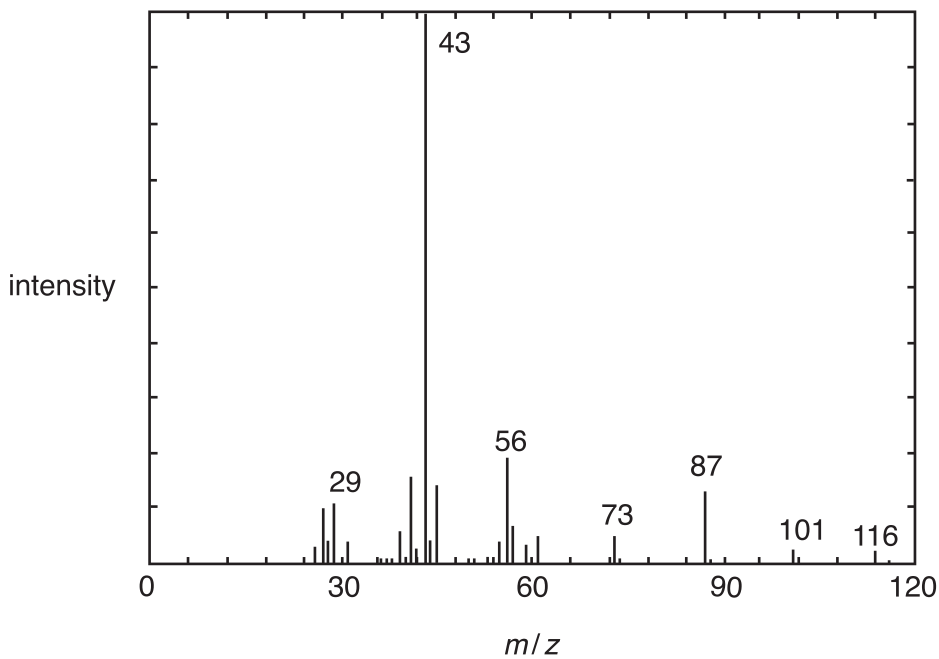
Alcohol **A**, $C_4H_{10}O$, is an isomer of butanol.
Alcohol **A** can be oxidised to compound **C** using acidified potassium dichromate(VI).

The infrared spectrum of compound **C** is shown below.



Alcohol **A** reacts with a carboxylic acid **D** to give compound **E**.

The mass spectrum of compound **E** is shown below.



Working shown on this page will not be marked

Using the information on page 8, determine the formulae of the **two** possible compounds that could be alcohol **A**. Determine the corresponding formulae for compounds **C** and **E**, and the formula of **D**.

Give full reasoning for all compounds.

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.... **[6]**

3 Bromomethane is a gas that is used as a fumigant to protect young plants against insects and rodents.

(a) It is possible to make bromomethane by reacting methane with bromine in the presence of light. This takes place by a radical chain reaction.

(i) Write an equation to show the effect of light on bromine in the initiation stage of this reaction.

[1]

(ii) The initiation stage is followed by the propagation stage which involves two steps.

The equation for the **first** propagation step is shown below.

$$CH_4 + Br^{\bullet} \rightarrow {}^{\bullet}CH_3 + HBr$$

Write the mechanism for the **second** propagation step using 'half curly arrows'. Indicate radicals with dots as above.

[2]

(iii) Bromomethane can also be made by treating methanol with hydrogen bromide.

Is this method or the reaction of methane and bromine preferable?

Give a reason for your answer.

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.... **[1]**

(b) A student predicts incorrectly that chloromethane will have a higher boiling point than bromomethane. The student's reason is that chlorine is more electronegative than bromine and thus the carbon to chlorine bond is more polar than the carbon to bromine bond. This will cause stronger permanent dipole-permanent dipole bonds.

Discuss the student's reasoning and give the correct chemistry where necessary.

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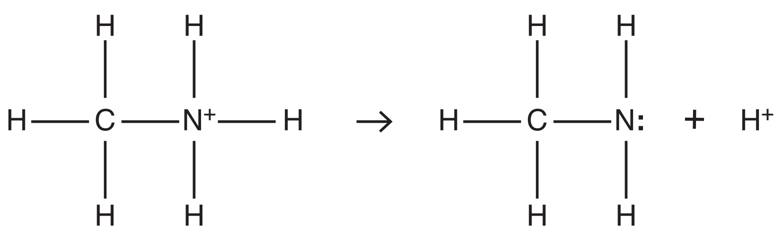
.... **[4]**

(c) Haloalkanes react with ammonia under suitable conditions.

(i) The first step in the mechanism of the reaction of bromomethane with ammonia involves the following reaction.

$$CH_3Br + NH_3 \rightarrow CH_3NH_3^+ + Br^-$$

Draw a 'curly arrow' to show the electron movement in the second step in the mechanism below.



[1]

(ii) Name the mechanism for the reaction of bromomethane with ammonia.

.... **[1]**

(iii) Name the functional group in the organic product of the reaction.

.... **[1]**

(d) A student investigates the rate of hydrolysis of haloalkanes.

Two test tubes, each containing aqueous silver nitrate and ethanol, are placed in a water bath at 60 °C. Five drops of each of chlorobutane and iodobutane are added separately to each of the two test tubes.

(i) Describe what the student would see as the reactions progress that would show that iodobutane reacts faster.

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.... **[1]**

(ii) Suggest why ethanol is used in the mixture.

....

.... **[1]**

(iii) Use the following data to explain whether bond enthalpy or bond polarity is the more important in determining the order of the rate of hydrolysis of haloalkanes.

Electronegativity	C*l* = 3.2	I = 2.7	C = 2.6
Bond enthalpy/kJ mol^{-1}	C–C*l* = +346	C–I = +228	

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.... **[3]**

(e) When bromomethane, CH_3Br, gets into the Earth's atmosphere, a C–Br bond may be broken by ultraviolet radiation from the Sun. However, the ultraviolet radiation may not have high enough energy to break the bond.

Suggest what other effect it may have on the molecule.

.... **[1]**

(f) The minimum frequency of radiation needed to break one C–Br bond is 7.14×10^{14} Hz.

Calculate the bond enthalpy of the C–Br bond, in kJ mol^{-1}.

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

bond enthalpy = ... kJ mol^{-1} **[3]**

(g) Ozone is present in both the troposphere (lower atmosphere) and the stratosphere (upper atmosphere).

(i) The ozone percentage concentration in the stratosphere is 0.000021% by volume.

Calculate the concentration of ozone in ppm (parts per million).

ozone concentration = ... ppm **[1]**

(ii) The process by which Br reacts with ozone in the stratosphere is represented in the following equations.

$Br + O_3 \rightarrow BrO + O_2$ **Equation 3.1**

$BrO + O \rightarrow Br + O_2$ **Equation 3.2**

Combine **equations 3.1** and **3.2** to produce the overall equation for the process.

[1]

(iii) Explain how **equations 3.1** and **3.2** show that Br could be a catalyst for the breakdown of ozone.

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.... **[1]**

(iv) Give **one** disadvantage of a build-up of **tropospheric** ozone.

.... **[1]**

4 Iodine can be extracted from the ash of burnt seaweed. The ash is washed with water. The washed ash is heated with manganese(IV) oxide, MnO_2, and concentrated sulfuric acid, forming iodine.

$$2I^- + MnO_2 + 4H^+ \longrightarrow Mn^{2+} + 2H_2O + I_2$$ **Equation 4.1**

(a) Complete the table below to show the oxidation states for manganese and iodine in the reaction shown in **equation 4.1**.

Element	Initial oxidation state	Final oxidation state
Mn		
I		

[1]

(b) The half-equation for the conversion of MnO_2 to Mn^{2+} ions is shown below.

$$MnO_2 + 4H^+ + 2e^- \longrightarrow Mn^{2+} + 2H_2O$$ **Equation 4.2**

Explain, in terms of electrons, why the manganese is said to be reduced.

.... **[1]**

(c) A student extracts iodine from seaweed ash in the laboratory. The student suspects that the water used to wash the ash contains a mixture of salts, including sodium chloride.

The student tests this water to see if it contains chloride ions by adding silver nitrate solution.

(i) Give the result of the test for chloride ions.

.... **[1]**

(ii) Suggest why the student might not get this result.

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.... **[2]**

(d) Iodine and chlorine are both members of the halogen group.

(i) Write the electron configuration for the highest energy sub-shell for an **iodide ion**.

.... **[1]**

(ii) A student carries out a displacement reaction to show that chlorine is more reactive than iodine.

Describe the experiment the student would do and the expected result.

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.... **[2]**

(iii) Write an ionic equation for the reaction in **(ii)**.

[1]

(iv) Describe and explain, in terms of electrons, why chlorine is more reactive than iodine.

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.... **[2]**

(e) The student collected 0.92 g of impure iodine, I_2, and decided to determine its purity.

The student dissolved the impure iodine in potassium iodide solution.
This iodine solution was then titrated with sodium thiosulfate solution.
The equation for the reaction is shown below.

$$I_2 + 2S_2O_3^{2-} \rightarrow 2I^- + S_4O_6^{2-}$$ **Equation 4.3**

The titration required 28.40 cm^3 of 0.200 mol dm^{-3} sodium thiosulfate solution.

Calculate the percentage purity of the iodine.

purity of iodine = ... % **[3]**

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).