Oxford Cambridge and RSA

Tuesday 12 October 2021 – Morning

A Level Chemistry B (Salters)

H433/02 Scientific literacy in chemistry

Time allowed: 2 hours 15 minutes

You must have:
- a clean copy of the Advance Notice Article (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 **100**.
- 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 **20** pages.

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

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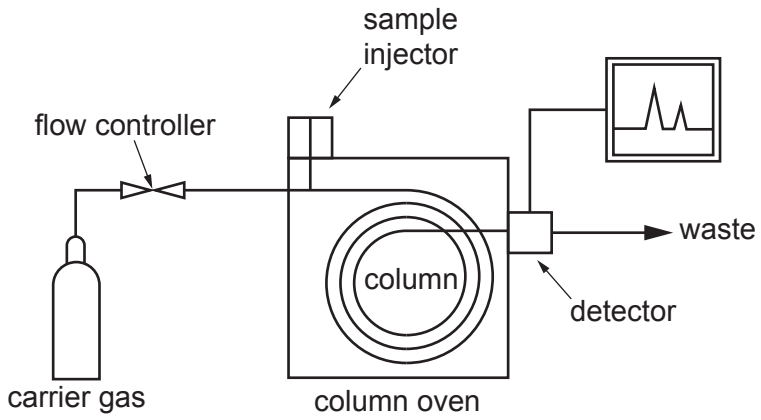
Answer **all** the questions.

1 Gas-liquid chromatography can be used to analyse the components of car petrol.



A gas chromatograph

(a) **(i)** State an important property of the carrier gas.

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

(ii) What does the column consist of?

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

(b) The first four components of a sample of petrol to emerge from the column are shown in **Table 1.1** in the order they come out.

1	methylbenzene
2	2-methylheptane
3	3-methylheptane
4	octane

Table 1.1

(i) Suggest the method used to identify these compounds as they emerge from the column.

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

(ii) Which of the compounds in **Table 1.1** has the shortest retention time?

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

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(c) Suggest, with reasons, which of compounds 2, 3 and 4 from **Table 1.1** has the highest boiling point.

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

(d) Octane can be cracked.

Write an equation for the cracking of octane into but-2-ene, $CH_3CH{=}CHCH_3$, and one other compound.

Use **molecular** formulae.

[1]

(e) Explain why but-2-ene has two stereoisomers.

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

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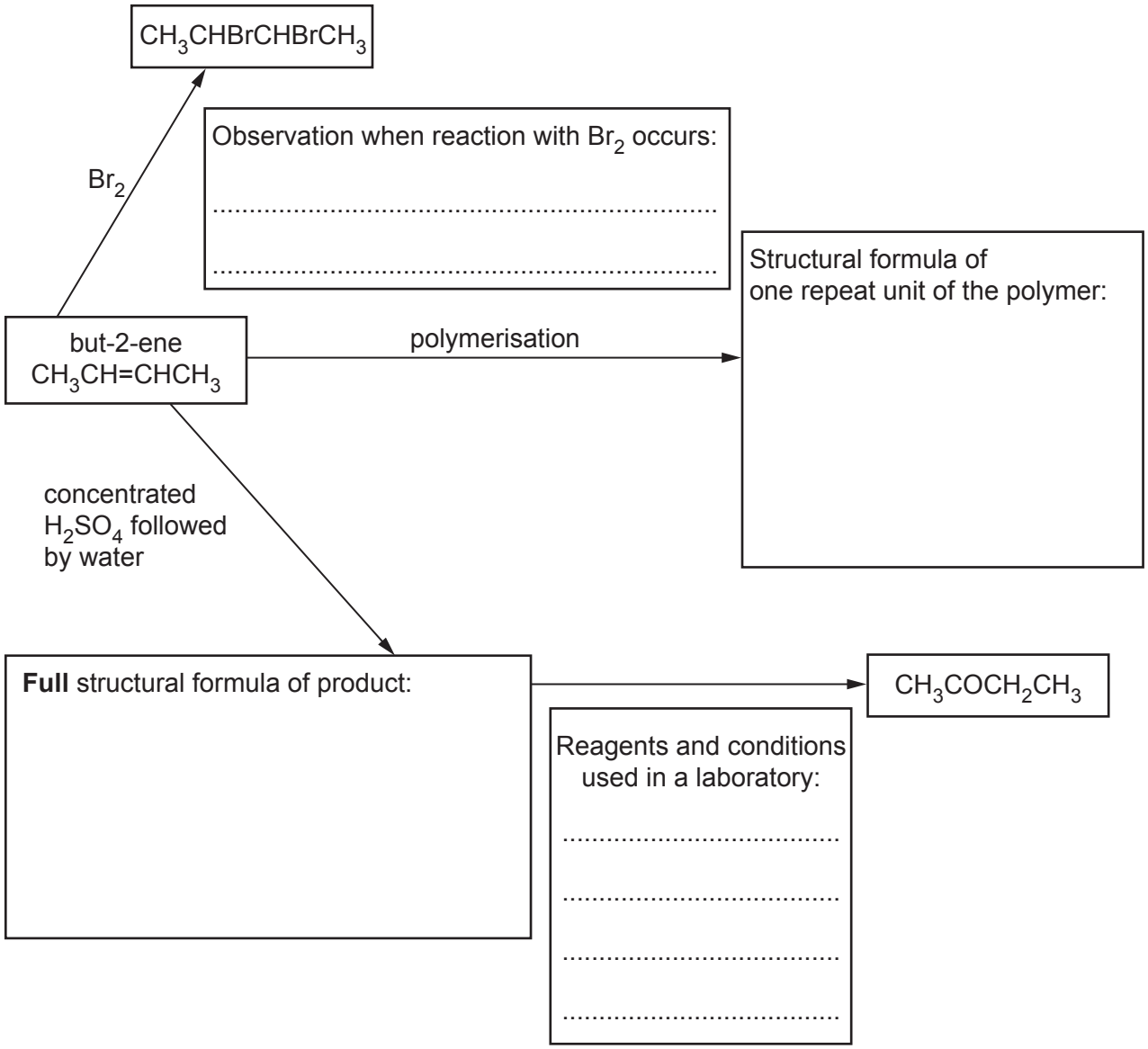
(f) Some reactions of but-2-ene are shown in the diagram below.

Complete the diagram by filling in the incomplete boxes.



[5]

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(g) A hydrocarbon is completely burned.
11 g of carbon dioxide and 6.0 g of water are formed.

Calculate the empirical formula of the hydrocarbon.

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

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2 Some students are investigating the rusting of iron.

They use the electrode potentials in **Table 2.1**.

	Half equation	$E^{\ominus}$ **/ V**
1	$Zn^{2+}(aq) + 2e^- \rightleftharpoons Zn(s)$	– 0.76
2	$Fe^{2+}(aq) + 2e^- \rightleftharpoons Fe(s)$	– 0.44
3	.....$O_2(g) + H_2O(l)$ + ...$e^- \rightleftharpoons 2OH^-(aq)$	+ 0.40

Table 2.1

(a) **(i)** Complete half-equation 3 in **Table 2.1** by writing numbers on the dotted lines. **[2]**

(ii) Use oxidation states to state and explain what is being reduced in half-equation 3 in **Table 2.1**.

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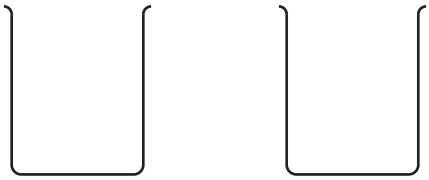
..... **[2]**

(b) The students set up a cell under standard conditions using half-equations 1 and 2 in **Table 2.1**. They aim to measure $E^{\ominus}_{cell}$.

(i) Complete the diagram of their apparatus.
Indicate how standard conditions are obtained.



[3]

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(ii) Use the data in **Table 2.1** to calculate the $E^{\ominus}_{cell}$ value for the cell in **(b)(i)**.

$E^{\ominus}_{cell}$ = ...V **[1]**

(c) Zinc blocks are often fixed to the bottom of steel ships to stop the ships rusting in sea water.

A student compares this process with the cell in part **(b)(i)**.

The student makes the following statements:

- Electrons flow from the iron (steel) to the zinc.
- This stops the rusting by reversing half-equation 2.
- The process is limited as there is no salt bridge.

Comment, with reasons, on the student's statements.

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

(d) The students add aqueous sodium hydroxide to a fresh aqueous solution of an iron(II) salt. A precipitate of iron(II) hydroxide forms that gradually turns to iron(III) hydroxide.

Write a full equation with state symbols for the formation of iron(III) hydroxide from iron(II) hydroxide.

[3]

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(e) The students are given a sample of 5.0 g of rust with the formula $Fe_2O_3 \cdot 2H_2O$.

The students heat the rust and find that it loses 1.0 g.

Show by calculation whether the students have the correct result.

[2]

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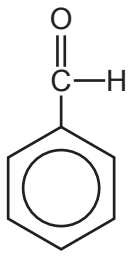
3 Benzaldehyde gives the smell and taste of almonds to almond oil.



benzaldehyde

(a) The mass spectrum of benzaldehyde has many peaks.
Two of the peaks have m/z values of 107 and 77.

Suggest explanations for these values.

107 .....

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77 .....

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[2]

(b) Benzaldehyde has a benzene ring.
The benzene ring has delocalised electrons.

Describe how the delocalised electrons are arranged in the benzene structure.

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

(c) Benzene and ethene each undergo electrophilic reactions.

State how these reactions differ.

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

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(d) Benzaldehyde can be nitrated to give nitrobenzaldehyde, which is yellow.

(i) A student says the colour occurs because nitrobenzaldehyde absorbs the complementary colour to yellow and emits yellow light.

Comment on the student's statement.

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

(ii) Calculate the wavelength (in cm) of the light associated with an electron energy change of 3.5×10^{-19} J.

wavelength = ... cm **[3]**

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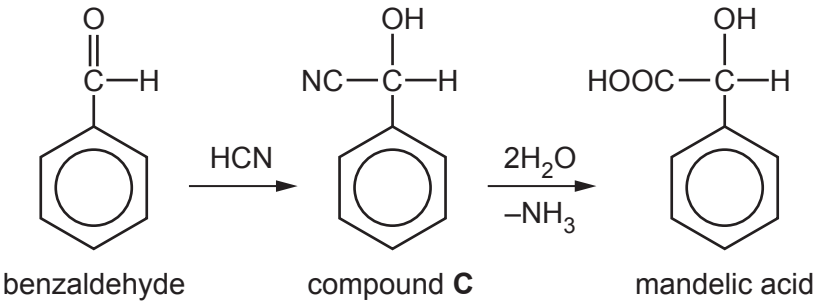
(e) Mandelic acid, an antibiotic, can be made from benzaldehyde.

The reaction scheme below shows a synthesis of mandelic acid.



(i) Draw the mechanism for the attack of a cyanide ion on benzaldehyde, followed by attack by H^+ to give compound **C**.

[2]

(ii) Name the functional group attached to the benzene ring in compound **C**.

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

(iii) In an experiment, 5.0 g of benzaldehyde gives 6.3 g of mandelic acid.

Calculate the percentage yield.

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

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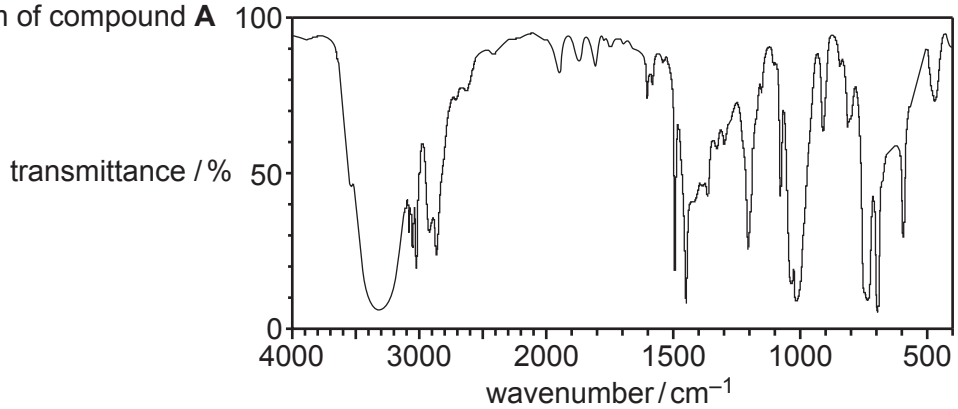
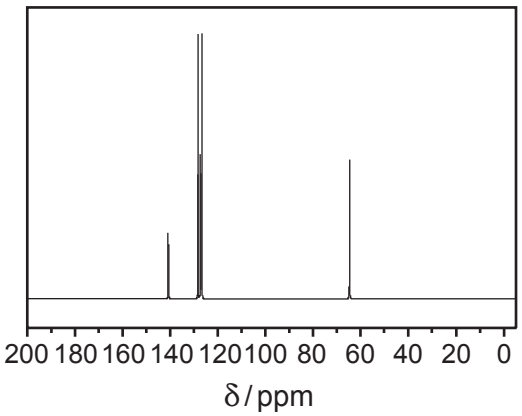
(f)* When benzaldehyde is reacted with alkali, and then neutralised, it forms two compounds, **A** and **B**.

Working may be done on this page but it will not be marked.

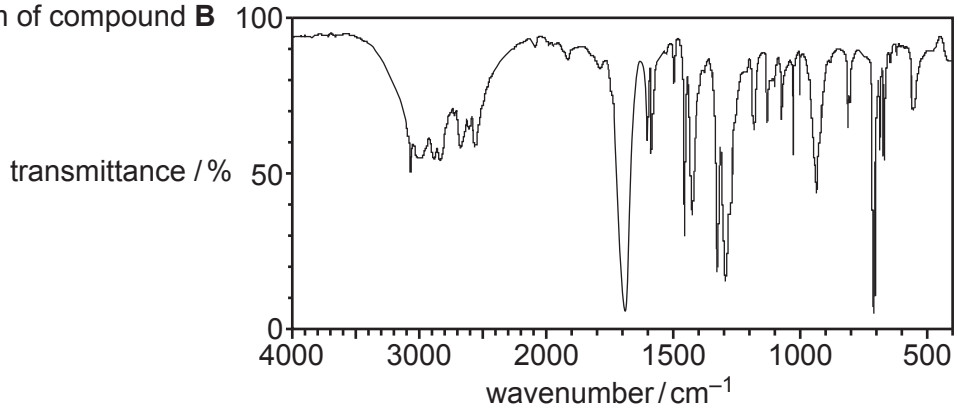
Infrared spectrum of compound **A**



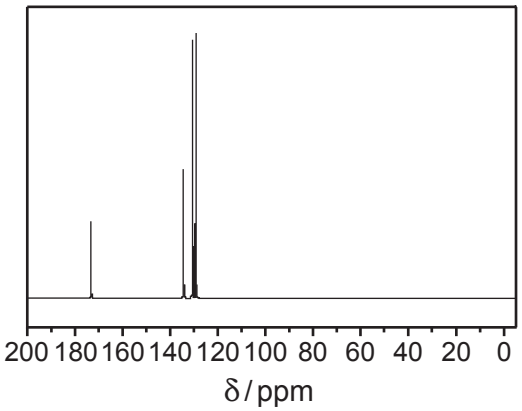
^{13}C – NMR spectrum of compound **A**



Infrared spectrum of compound **B**



^{13}C – NMR spectrum of compound **B**



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Use the spectra on page 12 to identify compounds **A** and **B**. Each one has seven carbon atoms.
Give full evidence from **all** the spectra, including relevant wavenumbers and chemical shifts.

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Additional answer space if required.

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4 Some students investigate the dissolving of potassium salts.

(a) The students are given 10.1 g of potassium nitrate, KNO_3.
They dissolve this in 150 cm^3 of water.

The temperature goes down by 5.3 °C.

(i) Give practical details of how they would carry out the experiment.

Include the apparatus required and the measurements to be made.

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

(ii) Use the students' result to calculate a value for $\Delta_{solution}H$ in $kJ\,mol^{-1}$.

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

Assume the solution has the same specific heat capacity and density as water.

$\Delta_{solution}H$ = ... $kJ\,mol^{-1}$ **[4]**

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(b) The students find the data below for dissolving another salt, KIO_3, in water.

$\Delta_{solution}H = +17.8\,kJ\,mol^{-1}$

$\Delta_{sys}S = +41\,JK^{-1}mol^{-1}$

(i) Explain the sign of $\Delta_{sys}S$ in terms of the particles involved in the process.

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

(ii) A student says that the dissolving of KIO_3 is not feasible below 434 K.

Carry out suitable calculations and comment on the student's statement.

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

(c) The students then discuss the enthalpy and entropy data for the industrial process shown in **Equation 4.1**.

$N_2(g) + O_2(g) \rightleftharpoons 2NO(g)\ \Delta H = +180\,kJ\,mol^{-1}$ **Equation 4.1**

(i) $\Delta_{sys}S$ is very small for the forward reaction.

Explain why, in terms of **Equation 4.1**.

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

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(ii)* A chemical company considers the conditions for making NO by the process shown in **Equation 4.1**.

Suggest and explain the conditions of temperature and pressure that you would recommend to the company for this process.

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Additional answer space if required.

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5 This question refers to the Advanced Notice Article 'Smartphones: Smart Chemistry' that is included as an insert with this paper.

(a) Lanthanide elements are important in smartphones.

The lanthanides can be described as being in a 'block' of the Periodic Table.

Use the electronic configurations of the lanthanides shown in the article to suggest the name of the block.

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

(b) The lanthanides were discovered using atomic emission spectroscopy.

(i) Describe the appearance of an atomic emission spectrum.

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

(ii) Describe how emission spectra are formed and explain how they allow different elements to be distinguished.

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

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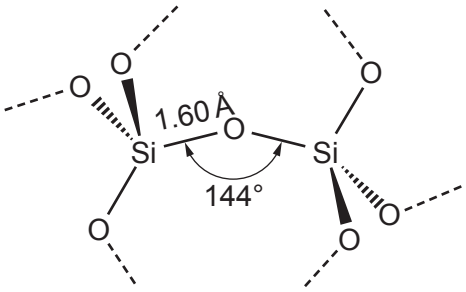
(c) The Article shows that the three-dimensional structure of silicon dioxide can be represented as shown below.



The Si-O-Si bonds have a larger angle than the H-O-H bond angle of water.

(i) State the H-O-H bond angle in a water molecule.

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

(ii) Explain the bond angle in water.

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

(d) Ceramics and 'gorilla glass' are both strong in resisting compression.

Which features of their chemical structures do they share and what does gorilla glass have in addition?

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

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(e) Explain why potassium ions can replace sodium ions in the structure of 'gorilla glass' and why potassium ions are larger.

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

(f) An aluminosilicate ion has the formula $Al_2Si_{14}O_{32}^{x-}$.

State and explain the value of *x* using oxidation states.

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

(g) Indium tin oxide consists of indium oxide and tin oxide and is used in capacitive touchscreens. Indium forms the oxide In_2O_3.

(i) Predict the charge on the indium ion from its position in the Periodic Table.

Use this to explain the formula In_2O_3.

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

(ii) The Article says that one form of indium tin oxide has percentages by mass: 53% In, 28% Sn and 19% O.

Show how the percentages by mass are related to the formulae of the oxides from which the indium tin oxide is made.

[2]

END OF QUESTION PAPER

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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).

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