



Oxford Cambridge and RSA

**Monday 19 June 2023 – Afternoon**

**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

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Candidate number

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First name(s)

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Last name

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**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 **24** pages.

**ADVICE**

- Read each question carefully before you start your answer.

- 1 The element bromine is extracted from seawater.

Bromide ions are present in seawater in very low concentrations compared with chloride ions.

- (a) (i) Excess chlorine is added to acidified seawater, forming aqueous bromine.

Write an **ionic** equation for the reaction of chlorine with bromide ions and explain how it shows that chlorine is more reactive than bromine.

Equation:

Explanation: .....

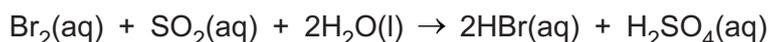
.....

[2]

- (ii) Air is blown through the mixture to remove the bromine as a vapour.

Sulfur dioxide is then added, and the mixture is dissolved in water.

Bromine reacts to form concentrated HBr.



What is the oxidising agent in this reaction?

Explain your answer using oxidation states.

.....

.....

.....

..... [2]

- (iii) Concentrated  $\text{Br}_2$  is made from the concentrated HBr by displacement using chlorine.

Complete the table to give the properties of chlorine, bromine and iodine.

Halogen	Colour at room temperature	Physical state at room temperature
chlorine		
bromine		
iodine		

[2]

(b) Some of the hazards of transporting bromine are similar to those of transporting chlorine.

Suggest **two** hazards of transporting bromine in a road tanker.

Hazard 1 .....

.....

Hazard 2 .....

.....

[2]

(c) Some students add aqueous silver nitrate to a sample of seawater.

They expect to see a cream precipitate of silver bromide but the precipitate is pure white.

(i) Write an **ionic** equation for the reaction of silver ions with **bromide** ions.

Show state symbols.

[2]

(ii) Suggest why the students do **not** get the result they expect.

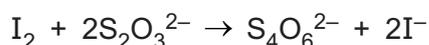
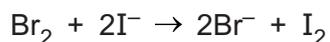
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..... [2]

(d) The students titrate 25.0 cm<sup>3</sup> of a solution of bromine with sodium thiosulfate in the presence of excess iodide ions.



They find that 24.65 cm<sup>3</sup> of 0.380 mol dm<sup>-3</sup> sodium thiosulfate is required to reach the end point.

Calculate the concentration of Br<sub>2</sub> in mol dm<sup>-3</sup>.

concentration = ..... mol dm<sup>-3</sup> [2]

4

(e) The students have another solution containing  $20 \text{ g dm}^{-3}$  bromine.

They find that  $160 \text{ cm}^3$  of this solution reacts exactly with  $0.80 \text{ g}$  of a hydrocarbon with a molecular formula of  $\text{C}_6\text{H}_8$ .

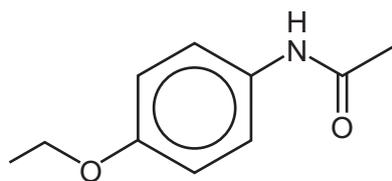
Suggest a structure for the hydrocarbon.

[4]

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**Turn over for the next question**

- 2 Phenacetin was used as a pain-relieving medicine until its harmful side-effects were discovered.



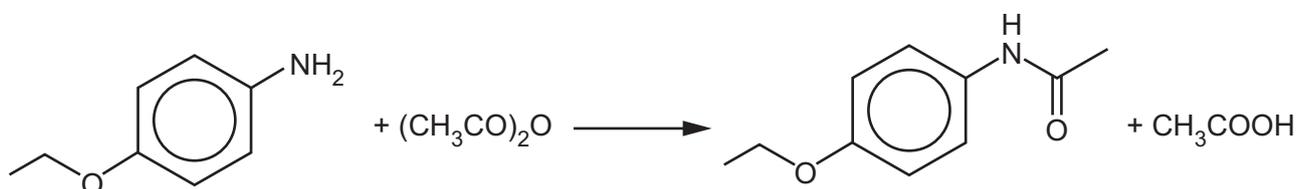
**Phenacetin**

- (a) Phenacetin has a secondary amide group attached to a benzene ring. It also has one other functional group.

Name this functional group.

..... [1]

- (b) Some students set out to make phenacetin from compound **A**, using the reaction shown.



**Compound A**

**Compound B**

**Phenacetin ( $M_r = 179$ )**

- (i) Give the systematic name of compound **B**.

..... [1]

- (ii) The students use 14 g of both compound **A** and compound **B**.

Calculate the amounts of each (in mol) that show that compound **B** is in excess.

amount of compound **A** = ..... mol

amount of compound **B** = ..... mol  
[2]

- (iii) The students recrystallise their crude phenacetin using water and obtain 20 g of solid product. They calculate their percentage yield.

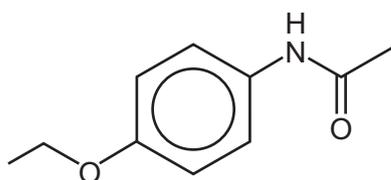
What advice would you give them?

.....

.....

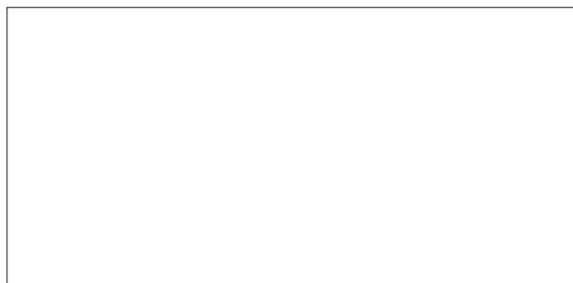
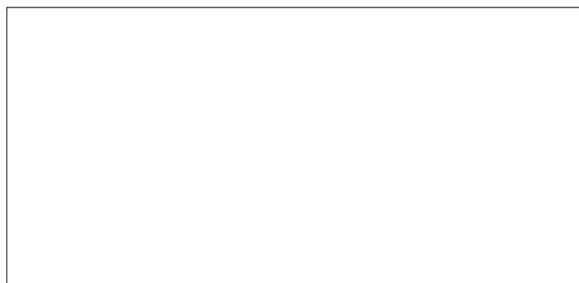
..... [3]

- (c) The students boil some phenacetin with aqueous acid.



**Phenacetin**

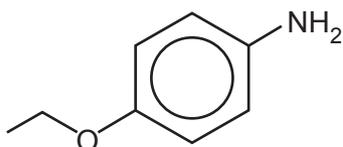
Draw the structures of the **two** products formed in the boxes below.



[2]

- (d) Compound **A** reacts with propanoyl chloride.

Draw the **skeletal** formula of the organic compound formed in the box below.



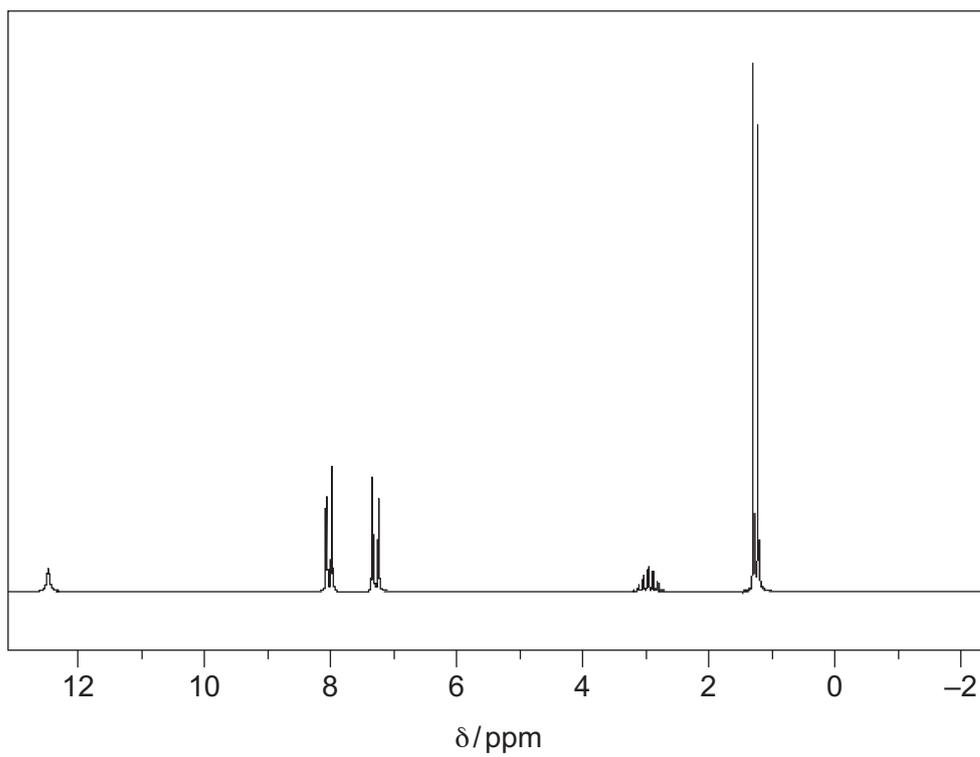
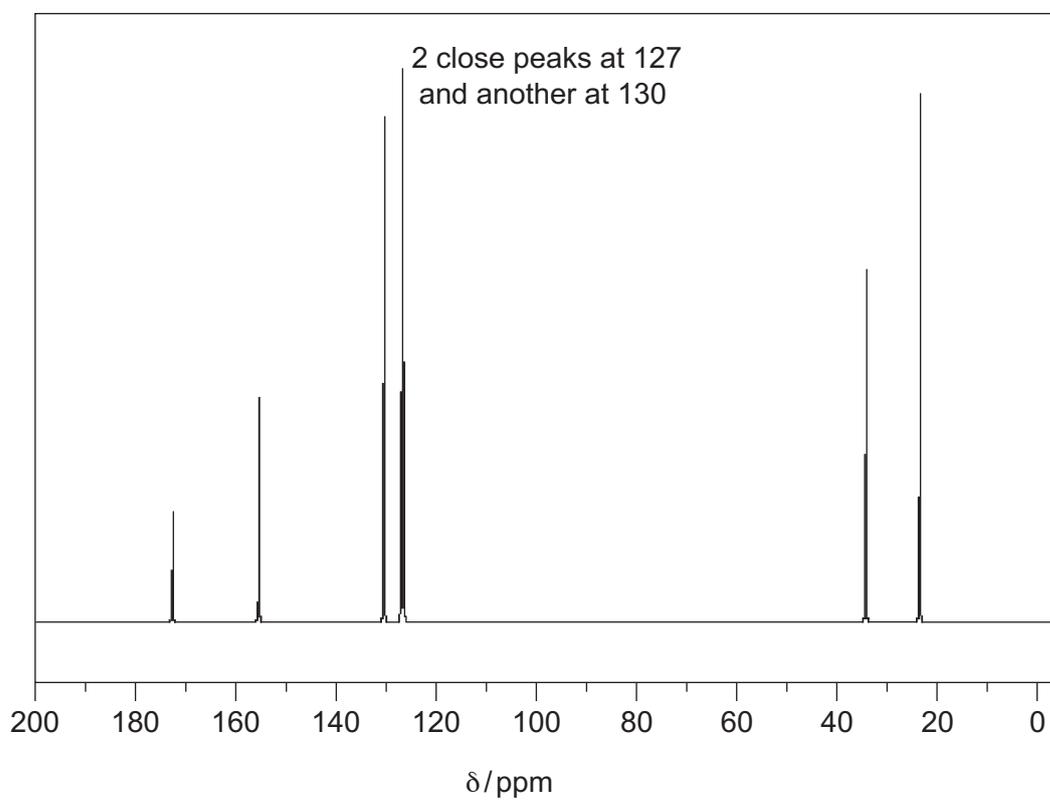
**Compound A**



[2]

8

(e)\* An aromatic acid has the formula  $C_{10}H_{12}O_2$ . Its NMR spectra are shown below.

 $^1H$  NMR $^{13}C$  NMR

You may do working on this page but only your answer on page 9 will be marked.





**Equation 3.1** is repeated.



$$K_c = \frac{[\text{CO}_2] [\text{H}_2]^4}{[\text{CH}_4] [\text{H}_2\text{O}]^2}$$

- (ii) A mixture of  $1.00 \text{ mol dm}^{-3} \text{ CH}_4(\text{g})$  and  $1.00 \text{ mol dm}^{-3} \text{ H}_2\text{O}(\text{g})$  is allowed to reach equilibrium at  $673 \text{ K}$  in a container of volume  $1.00 \text{ dm}^3$ .

The equilibrium concentration of  $\text{H}_2$  is found to be  $0.0705 \text{ mol dm}^{-3}$ .

Calculate a value for the equilibrium constant,  $K_c$ , for **Equation 3.1** at  $673 \text{ K}$  and give its units.

$$K_c = \dots\dots\dots \text{ units } \dots\dots\dots \quad [4]$$

- (iii)  $K_c$  for the reaction is then measured again at an increased pressure.

Would the value of  $K_c$  be larger, smaller or the same?

Give a reason for your answer.

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

**Equation 3.1** is repeated.



(iv) The table shows some entropy data.

Substance	$S^\circ / \text{J mol}^{-1} \text{K}^{-1}$
$\text{CH}_4(\text{g})$	186
$\text{CO}_2(\text{g})$	214
$\text{H}_2(\text{g})$	130
$\text{H}_2\text{O}(\text{g})$	189

Use the data to show that  $\Delta S^\circ_{\text{sys}} = +170 \text{ J mol}^{-1} \text{K}^{-1}$  for the reaction in **Equation 3.1**.

[1]

(v) Use calculations to determine if the forward reaction in **Equation 3.1** is feasible at  $750^\circ\text{C}$ .

Give a reason for your answer.

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

(vi) The carbon dioxide produced by the process in **Equation 3.1** is a greenhouse gas.

Describe **two** ways in which greenhouse gases in the troposphere cause warming when they are irradiated by infrared radiation from the Earth.

1 .....

.....

.....

.....

2 .....

.....

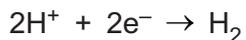
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[3]

(b) A potentially 'greener' method of making hydrogen is by electrolysis of acidified water.

(i) The equation for the reaction at the cathode is shown.



Complete and balance the equation for the reaction at the anode:



[2]

(ii) A mole of electrons is 96 500 coulombs. A coulomb is 1 amp flowing for 1 second.

How long (in hours) would it take for a current of 100.0 amps to produce 20.0 g of hydrogen by electrolysis?

Assume 100% efficiency.

time = ..... hours [3]

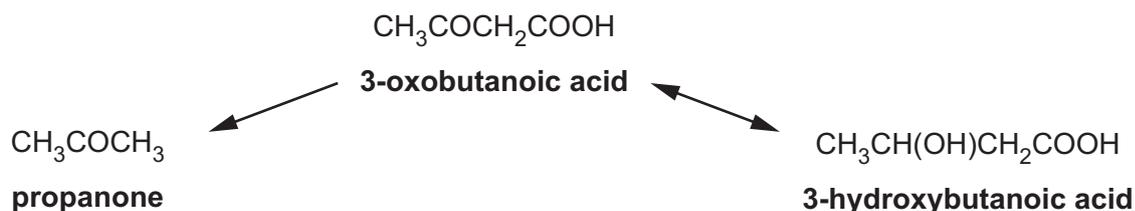
(iii) A student says that producing hydrogen by electrolysis is **not** 'green' because fossil fuels are used to make the electricity.

Discuss this statement.

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

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- 4 3-oxobutanoic acid is formed from carboxylic acids in the liver in the human body. It is then broken down to produce propanone and 3-hydroxybutanoic acid.



These three compounds are known as 'ketone bodies' and are always present in human blood.

- (a) Name the **type** of reaction by which 3-oxobutanoic acid is converted to 3-hydroxybutanoic acid.

..... [1]

- (b) A concentration of greater than  $6 \times 10^{-4} \text{ mol dm}^{-3}$  of ketone bodies in the bloodstream is known as 'ketosis'.

Calculate the **mass** of propanone ( $M_r$  58) (in grams) in  $100 \text{ cm}^3$  of blood that contains  $6 \times 10^{-4} \text{ mol dm}^{-3}$  of propanone.

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

mass = ..... g [2]

- (c) Ketosis can be detected by the presence of propanone in the breath.

Propanone can be recognised from its mass spectrum.

- (i) State a method of separating propanone vapour from human breath, allowing it to be analysed by a mass spectrometer.

..... [1]

- (ii) Peaks are found at  $m/z$  values 15, 43 and 59 in the mass spectrum of propanone ( $M_r$  58).

Give the origin of these peaks.

15 .....

43 .....

59 .....

[3]



Additional answer space if required:

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.....

.....

- (e) Classify propan-2-ol,  $\text{CH}_3\text{CH}(\text{OH})\text{CH}_3$ , as primary, secondary or tertiary and give a reason for your answer.

Classification (primary, secondary or tertiary) .....

Reason: .....

.....

[2]

- (f) Propan-1-ol is oxidised to an aldehyde rather than a ketone.

Describe a laboratory test, and its result, that would distinguish this aldehyde from propanone.

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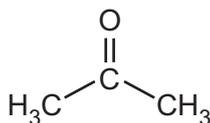
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..... [2]

- (g) Propanone reacts with  $\text{CN}^-$  ions in the presence of acid.

- (i) Complete the mechanism for this reaction.

Show curly arrows, charges, lone pairs and the product.



[3]

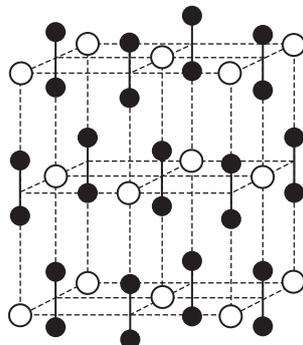
- (ii) Name the functional group formed in the product from (i).

..... [1]

5 This question concerns the Advance Notice Article 'Calcium carbide' that is included as an insert with this paper.

(a) A diagram of the structure of calcium carbide is shown below.

Label a cation and an anion to show how the ions are arranged in the structure.



[2]

(b) The industrial manufacture of calcium carbide has benefits and disadvantages for modern society.

From the article, suggest **two** benefits and **two** disadvantages.

Benefit 1 .....

.....

Benefit 2 .....

.....

Disadvantage 1 .....

.....

Disadvantage 2 .....

.....

[4]

- (c) 1.1 kg of a sample of impure calcium carbide produces  $0.33 \text{ m}^3$  of acetylene (at RTP) when reacted with water.

Calculate the percentage purity of the sample.

percentage purity = ..... % [3]

- (d) (i) Acetylene (ethyne) burns in a carbide lamp to form carbon dioxide and water. Some unreacted carbon is also formed that glows and gives light.

Write a possible chemical equation for the combustion of acetylene to give carbon dioxide and carbon.

[1]

- (ii) Impure calcium carbide contains calcium phosphide.

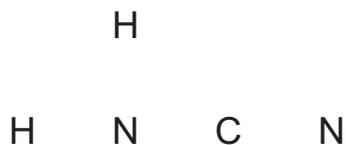
The phosphide ion is  $\text{P}^{3-}$ .

Calcium phosphide reacts with water to form  $\text{PH}_3$ .

Suggest a chemical equation for this reaction.

[2]

- (e) (i) Complete a 'dot-and-cross' diagram for cyanamide.



[2]

- (ii) Suggest, with reasons, the bond angle for N–C–N in cyanamide.

.....

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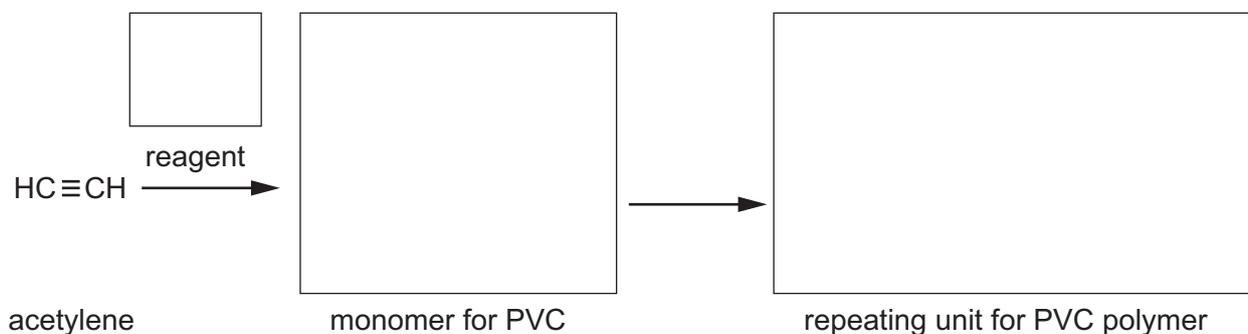
.....

..... [3]

- (f) PVC has the systematic name poly(chloroethene).

Complete the sequence below for the formation of PVC from acetylene.

Write a structural formula in each box.



[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).

A large area of lined paper for writing. It consists of a vertical solid line on the left side, creating a margin. To the right of this line, there are numerous horizontal dotted lines spaced evenly down the page, providing a guide for writing.

A blank sheet of lined paper. On the left side, there is a solid vertical line that serves as a margin. The rest of the page is filled with horizontal dotted lines, providing a guide for writing. The lines are evenly spaced and extend across the width of the page.

A blank sheet of lined paper. On the left side, there is a solid vertical line that serves as a margin. The rest of the page is filled with horizontal dotted lines, spaced evenly down the page, providing a guide for handwriting.

A large area of the page is filled with horizontal dotted lines, providing a space for writing answers. A solid vertical line runs down the left side of this area, creating a margin.

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