

## AS LEVEL

*Examiners' report*

# **CHEMISTRY A**

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**H032**

For first teaching in 2015

## **H032/02 Summer 2018 series**

Version 1

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## Introduction

Our examiners' reports are produced to offer constructive feedback on candidates' performance in the examinations. They provide useful guidance for future candidates. The reports will include a general commentary on candidates' performance, identify technical aspects examined in the questions and highlight good performance and where performance could be improved. The reports will also explain aspects which caused difficulty and why the difficulties arose, whether through a lack of knowledge, poor examination technique, or any other identifiable and explainable reason.

Where overall performance on a question/question part was considered good, with no particular areas to highlight, these questions have not been included in the report. A full copy of the question paper can be downloaded from OCR.

## Paper H032/02 series overview

H032/02 is one of the two examination components for the new revised AS Level examination for GCE Chemistry A. This synoptic depth in chemistry paper links together content from all four modules. To do well on this paper, candidates need to be comfortable applying their knowledge and understanding to unfamiliar contexts and be familiar with a range of practical techniques.

### **Candidates who did well on this paper generally did the following:**

- Performed standard calculations following the required rubric (e.g. clear working, units, significant figures): 1(c)(i), burette readings; 1(c)(ii), calculating the percentage uncertainty in a titre; 1(d)(i), calculating the molar mass from titration values; 3(c), bond enthalpies; 4(a)(ii), calculating the energy released; 5(a)(ii), calculating the mass of a reaction given the percentage yield; and 5(b), drawing and calculating a tangent.
- Produced clear and concise responses for Level of Response questions: 5(a)(i) and 7.
- Drew clear diagrams for organic structures: 1(d)(ii), 6(b)(ii), 6(c)(i) and 7.
- Constructed and balanced equations for unfamiliar reactions: 2(c)(ii).
- Applied knowledge and understanding to questions set in a novel context.

### **Candidates who did less well on this paper generally did the following:**

- Found it difficult to apply what they had learnt in practical situations. It was clear in 5(a)(i) that most candidates were not prepared to draw the practical equipment that they had used in the PAGs. Candidates had obviously revised the required reactions and wrote detailed descriptions of the reaction being carried out, but this was not what the question was asking of them.
- Produced responses that lacked depth: 4(c), 5(a)(i), 7. Question 5(a)(i) had relevant information that the candidates could use to answer the question in more depth, such as density of the product and boiling point, but this was often ignored. For question 7, many candidates did not use the mass spectrum data to aid their deduction for the correct structure.
- Showed poor setting out of unstructured calculations, e.g. 1(d)(i), 4(a)(ii).
- Showed poor presentation of observations and data in an appropriate format (Assessment Objective 1.2, 3.1, 3.2). e.g. 1(c)(i), 7.
- Lacked precision in balancing equations, particularly 2(c)(ii), 3(a)(i) and 6(c)(i) balancing the equation with  $n$ .

There was no evidence that any time constraints had led to a candidate underperforming and scripts where there was no response to the final question also had large sections of the paper which had not been tackled.

## Question 1(a)

- 1 A student carries out a titration to determine the molar mass and structure of a weak acid **A**.

The student follows the method below.

- Dissolve a weighed mass of **A** in  $100\text{cm}^3$  of distilled water and make the solution up to  $250\text{cm}^3$  in a beaker.
- Add the solution of **A** to a burette.
- Titrate the solution of **A** with a standard solution of sodium hydroxide, NaOH.

- (a) What is meant by the term standard solution?

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

Many candidates gave a good description of standard conditions or stated  $1\text{ mol dm}^{-3}$ , but that did not answer the question so no marks could be credited.

## Question 1(b)

- (b) Sodium hydroxide is an alkali.

What is meant by the term alkali?


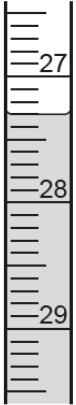

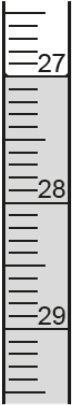
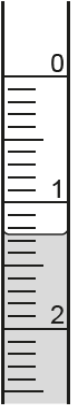
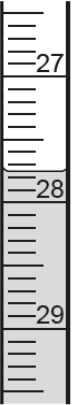
.....  
..... [1]

Many candidates stated a Brønsted–Lowry definition or gave pH values. Of the candidates that did mention  $\text{OH}^-$  ions, most did not state 'releases'  $\text{OH}^-$  ions in solution, although they were credited with the mark.

## Question 1(c)(i)

- (c) The student carries out a trial, followed by three further titrations. The diagram shows the initial and final burette readings for the three **further** titrations.

The student measures all burette readings to the nearest  $0.05\text{ cm}^3$ .

Titration 1		Titration 2		Titration 3	
Initial reading	Final reading	Initial reading	Final reading	Initial reading	Final reading
					

- (i) Record the student's readings and the titres in the table below.

Calculate the mean titre, to the nearest  $0.05\text{ cm}^3$ , that the student should use for analysing the results.

	Titration 1	Titration 2	Titration 3
Final reading/ $\text{cm}^3$			
Initial reading/ $\text{cm}^3$			
Titre/ $\text{cm}^3$			

mean titre = .....  $\text{cm}^3$  [4]

Most candidates were able to accurately record the burette readings and made the correct subtractions. Despite the examination question requesting the mean titre to be recorded to the accuracy of the burette, many candidates did not do this. A common error was taking a mean of all three readings instead of only the concordant results; this led the candidates to give an answer of 26.58 which lost them 2 marks.

## Question 1(c)(ii)

- (ii) The uncertainty in each burette reading is  $\pm 0.05 \text{ cm}^3$ .

Calculate the percentage uncertainty for the titre in **Titration 1**.

percentage uncertainty = ..... % [1]

A good attempt by many candidates but some did not know how to calculate this or did not multiply by 2.

## Question 1(c)(iii)

- (iii) The student realised that the solution of **A** had not been prepared correctly.

How should the student have made up the solution?

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

Although there were some excellent descriptions of the correct processes, such as inverting the apparatus to ensure mixing and then making the solution up to the mark, many candidates could not name a volumetric flask.

## Question 1(d)(i)

(d) A student repeats the titration to determine the molar mass and structure of **A**.

- The student prepares a 250.0 cm<sup>3</sup> solution from 1.513 g of **A**.
- The solution of **A** is added to the burette and titrated with 25.0 cm<sup>3</sup> volumes of 0.112 mol dm<sup>-3</sup> NaOH(aq).
- 1 mol of **A** reacts with 2 mol of NaOH.
- The student obtains a mean titre of 27.30 cm<sup>3</sup>.

(i) Calculate the molar mass of **A** from these results.

Give your answer to the nearest whole number.

Show your working.

molar mass of **A** = ..... g mol<sup>-1</sup> [4]

This was a good discriminator. Many candidates were credited the first two marks, and higher ability candidates went on to obtain 3 or 4 marks. Common errors were not rounding to a whole number at the end and not scaling up by 250/27.30. Many candidates did not scale up at all, obtaining an answer of 1081, or merely multiplied by 250/25 and obtained a molar mass of 108.



## Question 1(d)(ii)

- (ii) **A** is an organic acid, containing C, H and O only.  
One molecule of **A** contains two COOH groups.

Suggest the structure of **A**.

[1]

Most candidates that obtained a sensible value for the previous question managed to draw a creditable structure. Allowing error carried forward meant that feasibly derived structures could be credited a mark.

## Question 2(a)

- 2 Sodium sulfide, Na<sub>2</sub>S, is an ionic compound of sodium, Na, and sulfur, S.
- (a) Draw a 'dot-and-cross' diagram to show the bonding in sodium sulfide.  
Show outer electrons only.

[2]

The majority of candidates obtained full marks on this question. The most common errors were incorrect charges or covalent structures.

## Question 2(b)

(b) The table below compares the properties of sodium sulfide, sodium and sulfur.

Complete the table.

		Sodium sulfide	Sodium	Sulfur
Melting point/°C		1180	98	113
Type of structure (giant or simple)				
Electrical conductivity (good or poor)	solid			
	liquid			

[3]

The majority of candidates obtained 2 or 3 marks on this question. Many candidates seemed unaware that sodium was a metal.

## Question 2(c)(i)

(c) Selenium is in the same group of the periodic table as sulfur.

(i) Complete the full electron configuration of a selenium atom.

1s<sup>2</sup> ..... [1]

Most candidates answered this correctly. The most common error seen was 4p<sup>6</sup> instead of 4p<sup>4</sup>

## Question 2(c)(ii)

(ii) Sodium selenide reacts with hydrochloric acid to form a toxic gas, **B**, with a relative molecular mass of 81.0.

Identify gas **B** and write an equation for this reaction.

Gas **B** .....

Equation ..... [2]

The majority of candidates obtained 1 or 2 marks on this question. The most common errors seen were identifying the gas as H<sub>2</sub>S or incorrect balancing.

## Question 3(a)(i)

3 This question is about halogens.

(a) Bromine is used to extract iodine from a solution containing iodide ions.

(i) Write an ionic equation for the reaction.

..... [1]

Around 50% of candidates answered this correctly. The most common error was not balancing the equation, and many did not know what an ionic equation was.

## Question 3(a)(ii)

(ii) Explain why iodine is less reactive than bromine.

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

This question was answered well by most candidates, although some omitted the word 'nucleus' when explaining attracting electrons, or answered in terms of losing electrons, and did not have the final marking point credited.

## Exemplar 1

Iodine is less reactive than Bromine because it does not accept electrons as easily. This is because it has a larger atomic radius so the attraction from the nucleus on electrons is weaker. It is also subject to more electron shielding as it has more shells so energy levels. This also decreases <sup>nuclear</sup> attraction so it doesn't gain electrons as easily. [3]

This candidate was credited all three marks. Some candidates managed to be credited for all 3 marks in one short sentence that covered all 3 marking points.

## Question 3(b)(i)

(b) Iodine can be used for the small-scale purification of drinking water.

(i) Iodine reacts with water as shown below.



Using oxidation numbers, explain why this reaction is a disproportionation.

.....

.....

.....

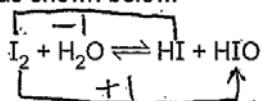
.....

..... [3]

Most candidates were aware of disproportionation but lost marks by not stating the species or whether the process was oxidation or reduction.

## Exemplar 2

(i) Iodine reacts with water as shown below.



Using oxidation numbers, explain why this reaction is a disproportionation.

Disproportionation is where the same element is both oxidised and reduced in the same reaction. Iodine is reduced to form HI and oxidised to +1 in HIO.

..... [3]

Here the candidate has lost a mark for not stating the initial oxidation number of elemental iodine as 0.

## Question 3(b)(ii)

(ii) Chlorine is used to purify water on a large scale.

State **one** disadvantage of using chlorine for the purification of drinking water.

.....

..... [1]

The majority of candidates stated that chlorine is toxic or forms carcinogens, although some stated that chlorine is a carcinogen which was not credited.

## Question 3(c)

(c) Hydrogen reacts with chlorine to form hydrogen chloride, HCl:

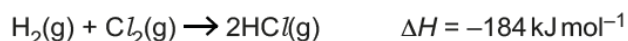


Table 3.1 shows bond enthalpies.

Bond	Bond Enthalpy/kJ mol <sup>-1</sup>
H-H	+436
Cl-Cl	+243

Table 3.1

Calculate the bond enthalpy for the H-Cl bond from the information above.

bond enthalpy = ..... kJ mol<sup>-1</sup> [2]

Most candidates made a good attempt at this question. The most common mistake was to use the wrong sign when incorporating the enthalpy change into the calculation, or not to incorporate it at all.

## Question 3(d)(i)

(d) 'Enthalpy change of vaporisation' is the enthalpy change when one mole of a substance changes from a liquid to a gas at its boiling point.

(i) Write an equation, including state symbols, to represent the enthalpy change of vaporisation of bromine.

..... [1]

A good attempt by many candidates but some lost marks by having the wrong state of bromine, even though the question stated it was a liquid changing to a gas. Many added water or oxygen, some confused the equation with bond enthalpy and answers such as  $\text{Br}_{2(l)} \rightarrow 2\text{Br}_{(g)}$  were commonly seen.

## Question 3(d)(ii)

- (ii) Suggest whether the enthalpy change of vaporisation of bromine is exothermic or endothermic.

Explain your answer.

.....

.....

..... [1]

The majority of candidates answered this question incorrectly. Only 10% of candidates mentioned intermolecular/London forces. Most stated 'exothermic' or described breaking covalent bonds.

## Question 4(a)(i)

- 4 The reaction of ammonia,  $\text{NH}_3$ , with oxygen to form nitrogen monoxide,  $\text{NO}$ , is an important industrial process.

The equation for this reaction is shown in **equilibrium 4.1** below.

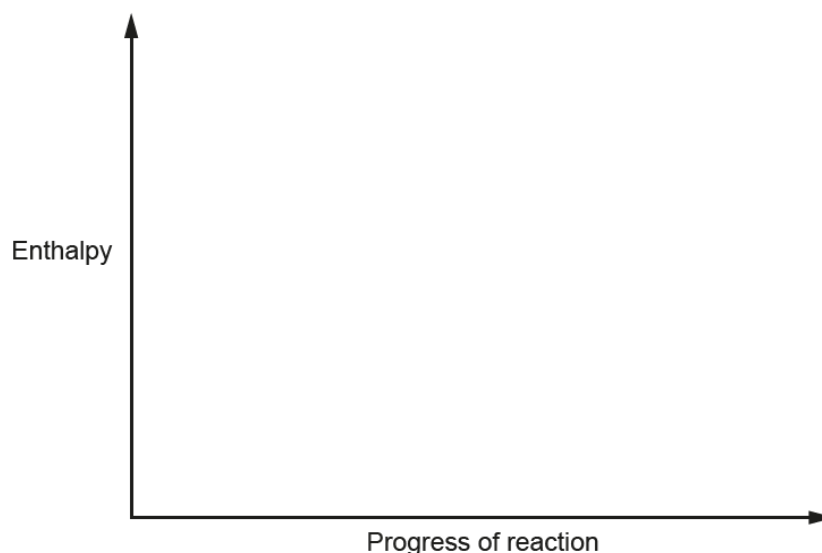


- (a) The forward reaction in **equilibrium 4.1** converts  $\text{NH}_3$  into  $\text{NO}$ .

- (i) Complete the enthalpy profile diagram for this reaction.

On your diagram:

- Label the activation energy,  $E_a$
- Label the enthalpy change of reaction,  $\Delta H$
- Include the formulae of the reactants and products.



[2]

Most candidates were able to gain the first mark, but many lost the second mark by putting a double headed arrow or  $-\Delta H$ .

## Question 4(a)(ii)

- (ii) 5.10 tonnes of  $\text{NH}_3$  are converted into NO.

Calculate the energy released, in kJ, for this conversion.

Give your answer in **standard form** and to an **appropriate** number of significant figures.

energy released = ..... kJ [4]

Most candidates were able to convert from tonnes to moles and then went on to complete the majority of the calculation steps. Many omitted to divide by 4 and were credited 3 marks. Some candidates lost marks by not stating the answer to standard form or quoted their answer to more than 3 significant figures. A number of candidates attempted to use  $Q = mc\Delta T$  and did not get very far in the calculation.

## Question 4(b)

- (b) Write an expression for the equilibrium constant,  $K_c$ , in **equilibrium 4.1**.

[1]

Generally, this question was well answered with only a small proportion of candidates adding the values together instead of multiplying.





## Exemplar 3

(c) Predict the conditions of temperature and pressure for a maximum equilibrium yield of nitrogen monoxide in equilibrium 4.1.

- Explain your prediction in terms of Le Chatelier's principle.
- State and explain how these conditions could be changed to achieve a compromise between equilibrium yield, rate and other operational factors.

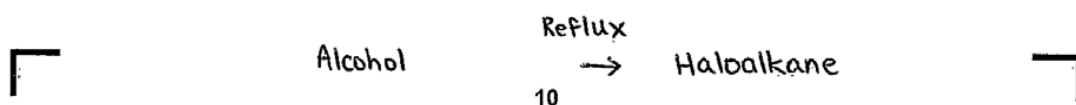
T ↓    P ↓

low temperature so as to shift the position of equilibrium to the right while favouring forward reaction. This is because forward reaction is exothermic ( $\Delta H = -ve$ ). low pressure so as to shift position of equilibrium to the right, as a decrease in pressure causes the equilibrium to move towards the direction with more gas molecules (right). These two conditions will minimise the change caused so maximum product (i.e. NO and  $N_2O$ ) are formed. A higher temperature is used so as to increase the rate of reaction. Otherwise reaction is too slow. A slightly higher pressure is also used to increase reaction rate but not too high pressure as it is dangerous and does not promote safety for workers.

This candidate scored all five marks for this well-reasoned approach to the question.



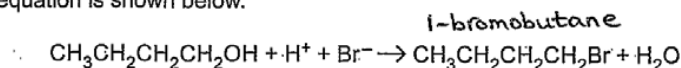
## Exemplar 4



- 5 (a) 1-Bromobutane is an organic liquid with a boiling point of 102°C.

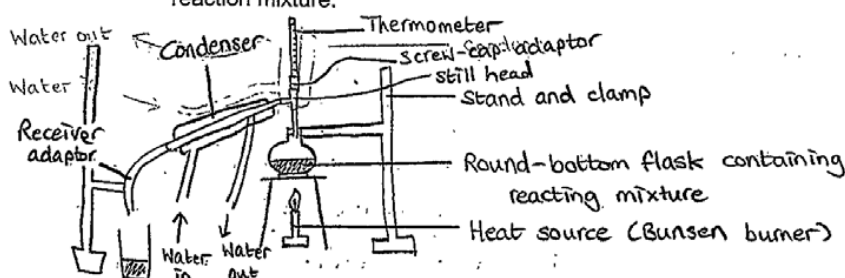
A student prepares 1-bromobutane by reacting butan-1-ol with sulfuric acid and sodium bromide. The student boils the mixture for one hour.

The equation is shown below.



The student obtains a reaction mixture containing an organic layer (density = 1.27 g cm<sup>-3</sup>) and an aqueous layer (density = 1.00 g cm<sup>-3</sup>).

- (i)\* Draw a labelled diagram to show how you would safely set up apparatus for the preparation. Outline a method to obtain a pure sample of 1-bromobutane from the reaction mixture.



~~Heat under reflux. Do~~ Perform a distillation. Heat the reaction mixture in a round-bottom flask at just over 102°C. The butan-1-ol will react with sulfuric acid and sodium bromide to form 1-bromobutane, which evaporates and condenses and is collected in a flask. Water has a boiling point of 100°C so also evaporates and condenses and collects in the flask.

Add the mixture in the collecting flask to a separating funnel. The organic layer should settle below the aqueous layer as it is denser. To confirm, add <sup>distilled</sup> water to the separating funnel, invert the funnel, and allow the layers to settle. The layer that gets bigger is the aqueous layer. Open the tap and run off the lower organic layer into a conical flask.

Add a drying agent to remove traces of water.

This candidate was credited 4 marks for this level 2 answer. Although they have drawn distillation apparatus instead of reflux, they have considered the boiling point of the product, detailed using a separating funnel, a drying agent and that the lower organic layer would be drawn off first.

## Question 5(a)(ii)

- (ii) The student used 0.150 mol of butan-1-ol. The student obtained a 61.4% percentage yield of 1-bromobutane.

Calculate the mass of 1-bromobutane obtained.

Give your answer to **three** significant figures.

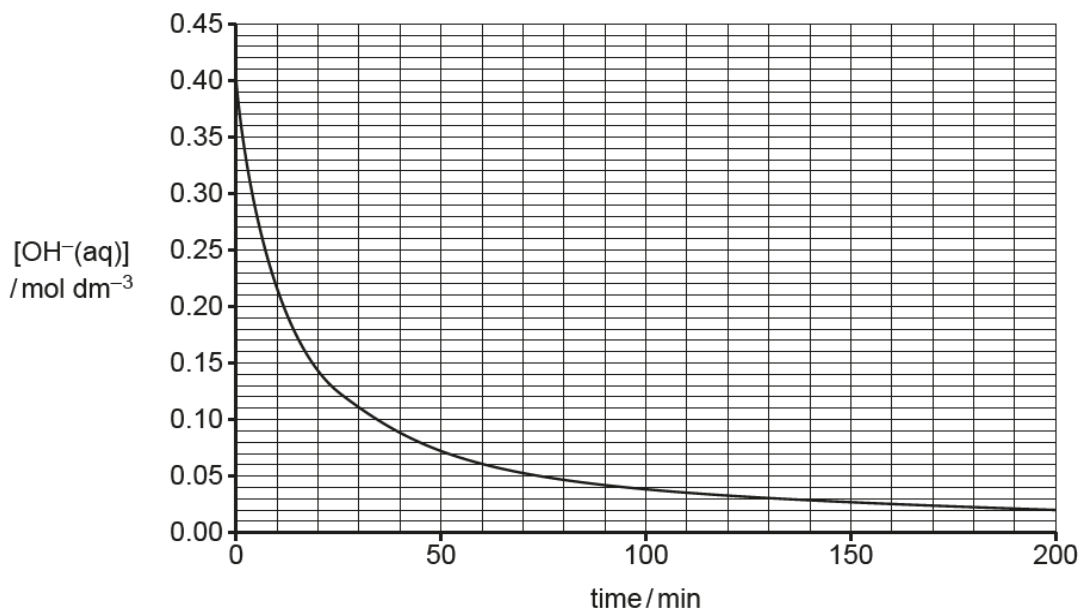
mass = ..... g [2]

This question was well answered, but a significant number of candidates incorrectly used the Mr of butan-1-ol when calculating the mass of 1-bromobutane.

## Question 5(b)

(b) A student investigates the rate of reaction of 1-bromobutane with aqueous hydroxide ions.

The graph shows how the hydroxide ion concentration,  $[\text{OH}^-(\text{aq})]$ , changes during the reaction.



Using the graph, calculate the rate of reaction, in  $\text{mol dm}^{-3} \text{min}^{-1}$ , at 30 minutes.

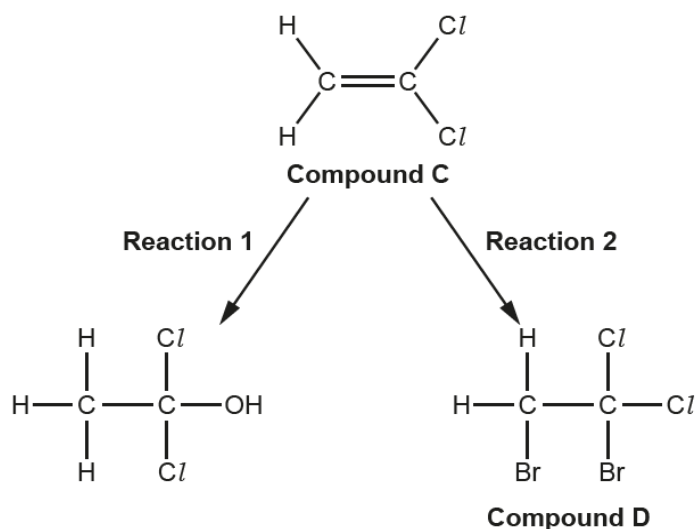
Show your working on the graph and in the space below.

rate of reaction = .....  $\text{mol dm}^{-3} \text{min}^{-1}$  [2]

Most candidates knew they had to draw a tangent to the curve but calculating the gradient led to careless errors. Many drew tiny triangles and mis-read readings of coordinates. It is far easier, and more accurate, to use large triangles using the axes for coordinates. Lower ability candidates just interpolated the graph at 30s and were not credited marks for this.

## Question 6(a)

6 Two reactions of compound **C** are shown in the flowchart below.



(a) State the reagents and conditions for **reaction 1**.

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

Many candidates knew the answer to this question but forgot that water must be in the gaseous state. There were numerous responses stating nickel as the catalyst, but most knew that an acid catalyst was required.

## Question 6(b)(i)

(b) In **reaction 2**, compound **C** reacts with bromine to form compound **D**.

(i) Give the systematic name of compound **D**.

..... [1]

This question was generally well answered, although some candidates made careless mistakes such as not writing -di or writing 1,2-dibromo-1-dichloroethane

## Question 6(b)(ii)

- (ii) Outline the mechanism for **reaction 2**.

Include curly arrows, charges and relevant dipoles.

[3]

Many candidates gained all three marks on this question and the diagrams were clear and easy to read. Lower ability candidates had incorrect dipoles or curly arrows that could not be traced back to the correct origin. Candidates should be encouraged to consider what the arrows mean rather than memorising mechanisms with no understanding.

## Question 6(c)(i)

- (c) Compound **C** forms an addition polymer **E**.

- (i) Write a balanced equation for this reaction.

Show displayed formulae.

[2]

Most candidates correctly drew the repeat unit and were credited with one mark, but many placed the  $n$  position in the wrong place on the left-hand side of the equation or forgot to write it in at all.

## Question 6(c)(ii)

- (ii) State **one** advantage and **one** disadvantage of using combustion as a method for the disposal of waste polymer **E**.

Advantage .....

.....

Disadvantage .....

..... [2]

With all the media interest in plastic pollution this question was answered well, although many gave the answer 'quick and efficient' as an advantage which was not credited. Candidates should beware of vague statements such as these. Many wrote 'harmful' instead of toxic, or 'bad for the environment' instead of being specific about the environmental issue.



## Question 7\*

7\* Compound **F** is a *trans* stereoisomer which is a useful intermediate in organic synthesis.

The results of elemental and spectral analysis of compound **F** are shown below.

Percentage composition by mass: C, 68.6 %; H, 8.6 %; O, 22.8 %.

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## Exemplar 5

In the mass spectrum, the peak with the greatest relative intensity is caused by the loss of a functional group from the molecular ion of compound F.

Determine the structure of compound F.

Explain your reasoning and show your working.

$$\begin{aligned} \text{C:H:O} &= \frac{68.6}{12} : \frac{8.6}{1} : \frac{22.8}{16} \\ &= 5.716\text{...} : 8.6 : 1.425 \\ &= 4.011\text{...} : 6.03\text{...} : 1 \end{aligned}$$

Empirical formula of compound F is  $\text{C}_4\text{H}_6\text{O}$ .

The  $M^+$  peak on <sup>the</sup> mass spectrum ~~is~~ <sup>has</sup> at an  $m/z$  value of 70, so the molecular mass of compound F is  $70 \text{ g mol}^{-1}$ ,

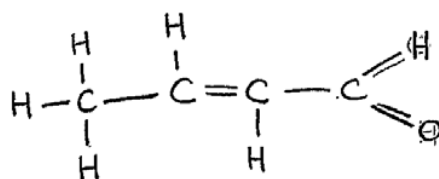
so the molecular formula of compound F is  $\text{C}_4\text{H}_6\text{O}$ .

The infrared spectrum shows an absorbance peak ~~at~~ in the range  $1630\text{--}1820 \text{ cm}^{-1}$ , indicating the presence of a  $\text{C}=\text{O}$  bond. There is <sup>broad</sup> no absorbance peak in the range  $2500\text{--}3300 \text{ cm}^{-1}$  so there is no  $\text{O-H}$  bond, so compound F

is not a carboxylic acid. ~~Compound~~ The mass spectrum shows a fragmentation peak at  $41 \text{ m/z}$ , indicating the presence of a  $\text{CH}_3\text{CHCH}^+$  fragment from the loss of [6]

a  $\text{CHO}$  functional group. Compound F is an aldehyde.

It is a trans ~~is~~ stereoisomer, so the hydrogens attached to the carbons on the double bond are opposite each other.

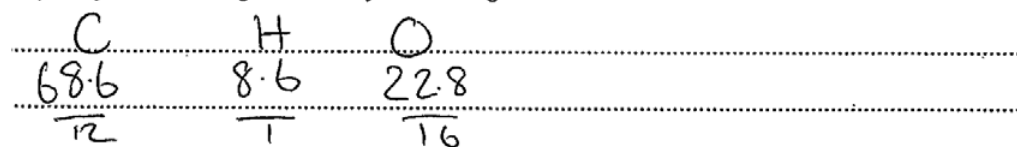


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This candidate has very logically worked through all the information provided and has come up with the correct structure from the deductions.

## Exemplar 6

Explain your reasoning and show your working.



$$= 5.716 : 8.6 : 1.425$$

$$= 4.0 : 6.0 : 1$$

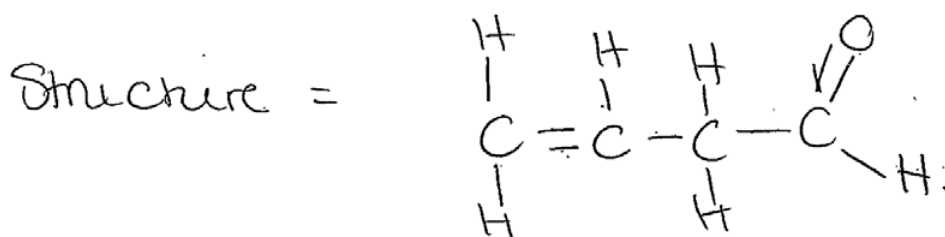
empirical formula =  $\text{C}_4\text{H}_6\text{O}$ .

$$\text{Mr} : (12 \times 4) + (6 \times 1) + (16) = 70$$

F.Mr = 70  $\rightarrow$  molecular formula =  ~~$\text{C}_4\text{H}_6\text{O}$~~

Peak at  $29^+$   $\rightarrow$   ~~$\text{C}=\text{O}$~~  } mass spectrum.  
Peak at 41  $\rightarrow$   $\text{H}_2\text{C}=\text{CH}_2\text{CH}_2$  S

IR Spectrum  $\rightarrow$  Peak at  $1630-1820\text{cm}^{-1}$  indicates the presence of a  $\text{C}=\text{O}$  group  
 $\rightarrow$  Peak at  $1620-1680\text{cm}^{-1}$  indicates the presence of a  $\text{C}=\text{C}$  group.



Like most candidates, the crucial information about F being a *trans* isomer was not picked up so they drew the double bond in the wrong place.

### Copyright acknowledgements

Q7, graph 1

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Q7, graph 2

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