

**Advanced GCE
CHEMISTRY A**

F324 QP

Unit F324: Rings, Polymers and Analysis

Specimen Paper

Candidates answer on the question paper.

Time: 1 hour 15
minutes

Additional Materials:
Data Sheet for Chemistry (Inserted)
Scientific calculator

Candidate
Name

Centre
Number

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Candidate
Number

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INSTRUCTIONS TO CANDIDATES

- Write your name, Centre number and Candidate number in the boxes above.
- Answer **all** the questions.
- Use blue or black ink. Pencil may be used for graphs and diagrams only.
- Read each question carefully and make sure you know what you have to do before starting your answer.
- Do **not** write in the bar code.
- Do **not** write outside the box bordering each page.
- WRITE YOUR ANSWER TO EACH QUESTION IN THE SPACE PROVIDED.

INFORMATION FOR CANDIDATES

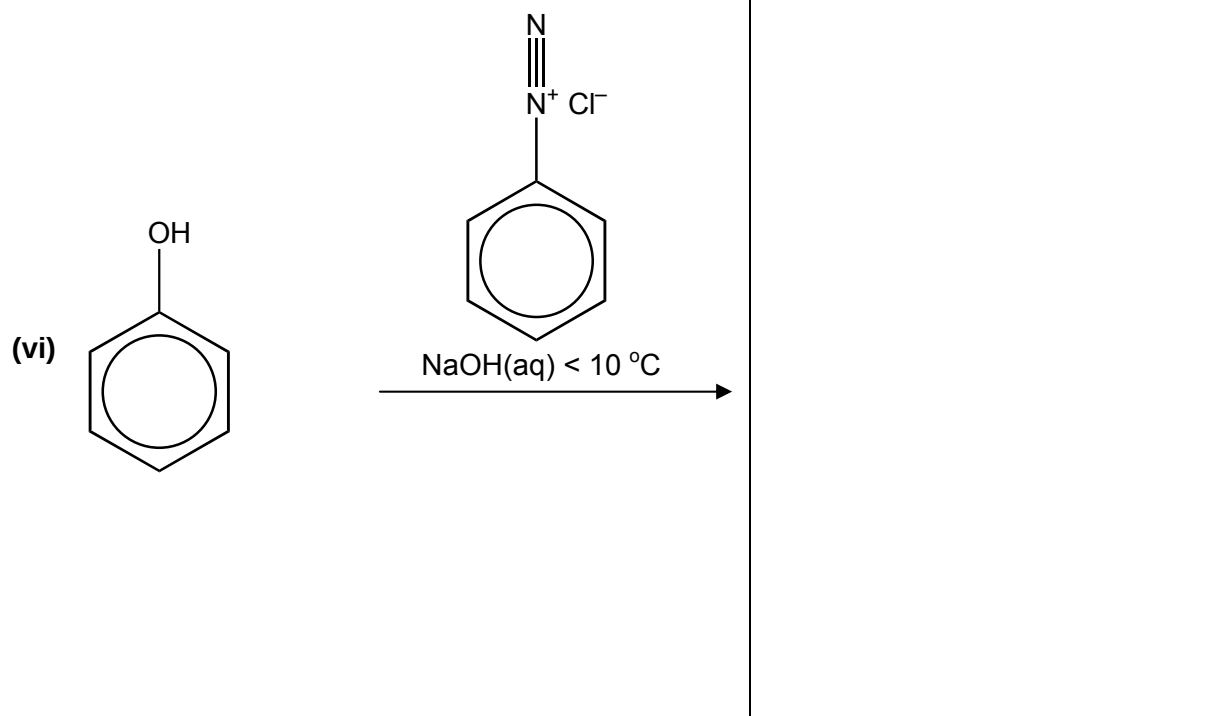
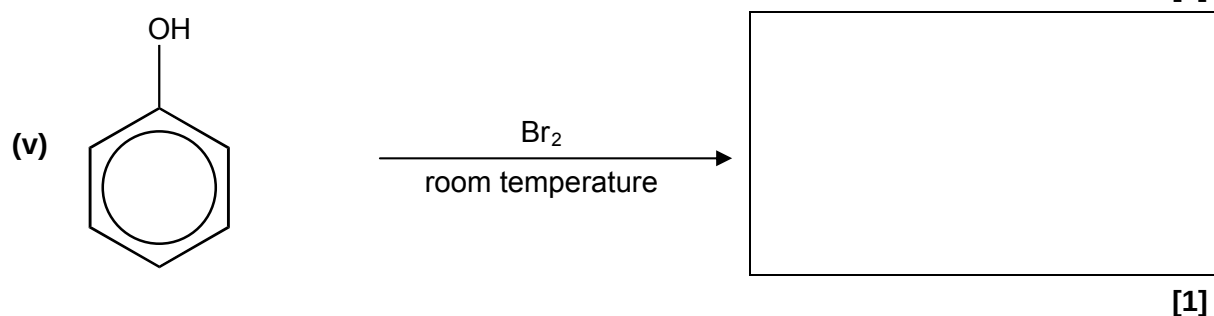
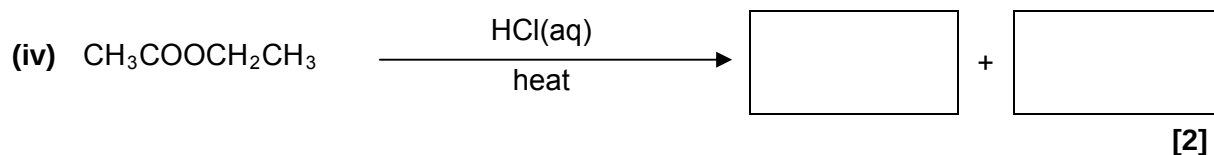
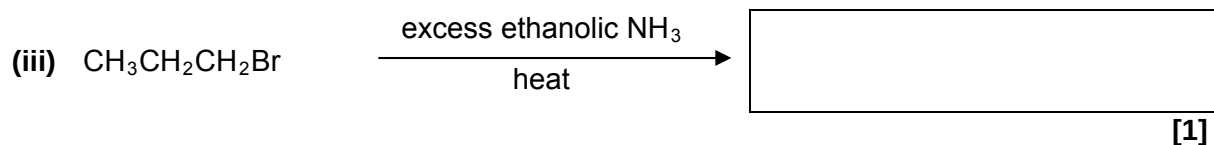
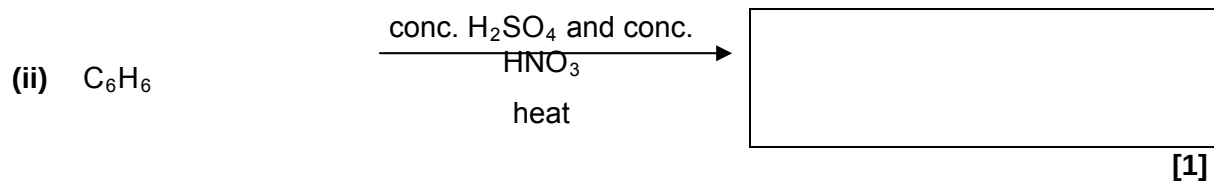
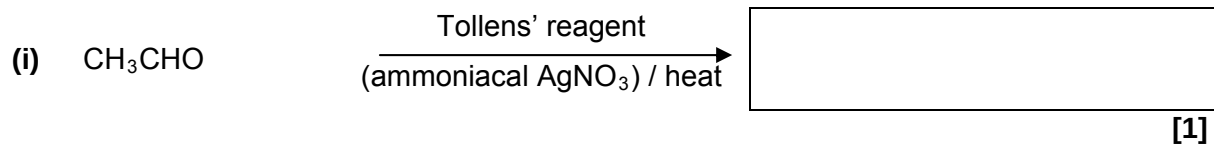
- The number of marks is given in brackets [] at the end of each question or part question.
-  You will be awarded marks for the quality of written communication where this is indicated in the question.
- You may use a scientific calculator.
- A copy of the *Data Sheet for Chemistry* is provided as an insert with this question paper.
- You are advised to show all the steps in any calculations.
- The total number of marks for this paper is **60**.

FOR EXAMINER'S USE		
Qu.	Max.	Mark
1	16	
2	13	
3	14	
4	10	
6	7	
TOTAL	60	

This document consists of **10** printed pages, **2** blank pages and a *Data Sheet for Chemistry*.

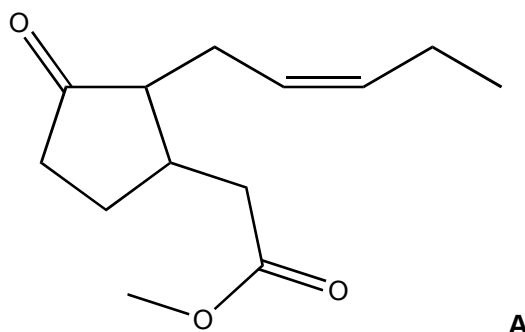
Answer **all** the questions.

1 (a) Complete the reactions by drawing structural formulae in each of the boxes provided.



[2]

- (b) Compound **A**, shown below, contributes to the smell and taste of black tea and is a component in jasmine oil.



- (i) Deduce the molecular formula of compound **A**. [1]

- (ii) Compound **A** contains several functional groups.

Identify, by **name**, the functional groups in compound **A**.

.....

 [3]

- (iii) Compound **A** is a stereoisomer.

On the structure above,

- mark each feature responsible for stereoisomerism with an asterisk, * ,
- label each feature with the type of stereoisomerism. [2]

- (iv) Outline **two** important factors that pharmaceutical companies need to consider when manufacturing chiral compounds for use as medicines.

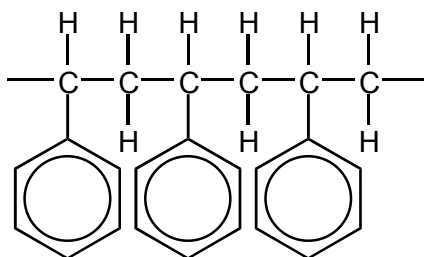
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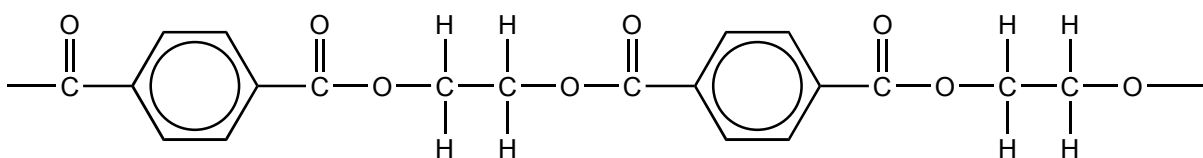
[Total: 16]

[Turn over]

2 Short sections of the molecular structures of two polymers are shown below.



polymer C



polymer D

- (a) (i) Circle, on the diagrams above, the simplest repeat unit in each polymer. [2]
- (ii) In the boxes below, draw the displayed formulae of the two monomers that could be used to prepare polymer D.

--	--

[2]

- (b) Chemists have developed degradable polymers to reduce the quantity of plastic waste being disposed of in landfill sites. Polymer D is more likely to be a 'degradable polymer' than polymer C.

Suggest **two** reasons why.

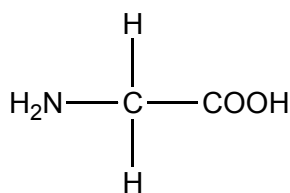
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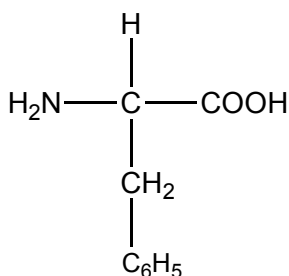
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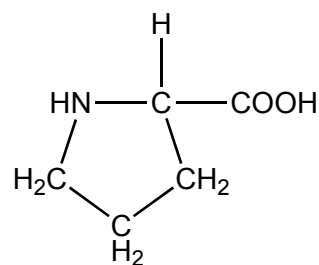
- (c) Amino acids can act as monomers in the formation of polypeptides and proteins. The structures below show three amino acids, glycine, phenylalanine and proline.



glycine



phenylalanine



proline

Glycine, phenylalanine and proline can react together to form a mixture of tripeptides.

- (i) Draw the structure of the **tripeptide** formed in the order glycine, phenylalanine and proline.

[3]

- (ii) How many different **tripeptides** could have been formed containing glycine, phenylalanine and proline?

..... [1]

- (iii) The mixture of tripeptides can be analysed by using gas chromatography, coupled with mass spectrometry.

Summarise how each method contributes to the analysis.

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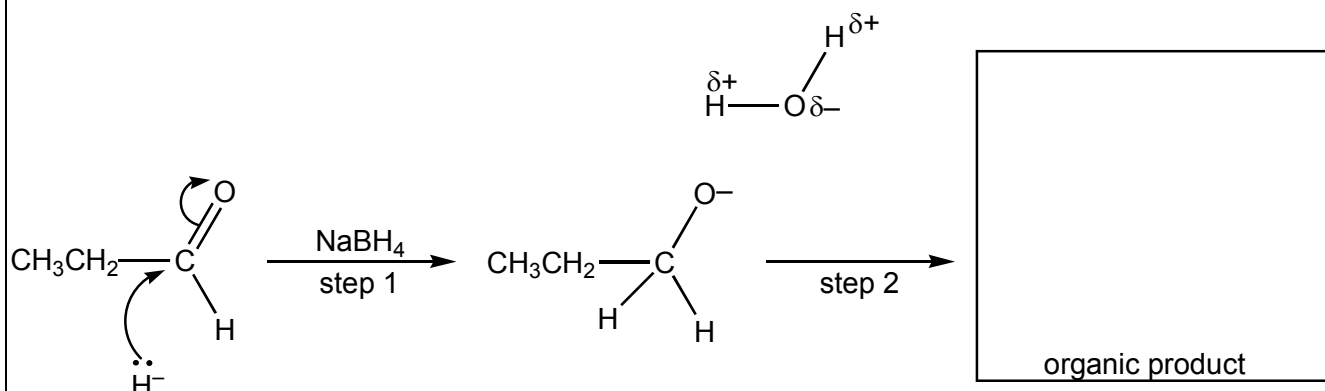
..... [3]

[Total: 13]

[Turn over]

3 Propanal, $\text{CH}_3\text{CH}_2\text{CHO}$, can be used in the synthesis of organic compounds.

- (a) $\text{CH}_3\text{CH}_2\text{CHO}$ reacts with NaBH_4 in a nucleophilic addition reaction. The nucleophile can be represented as a hydride ion, H^- . A mechanism for the reaction is shown below.



- (i) Add 'curly arrows' to the mechanism to show how the intermediate reacts with the water molecule in **step 2**. [2]
- (ii) Draw the structure of the organic product in the box above. [1]
- (iii) What is meant by the term *nucleophile*? [1]

- (iv) Describe, in words, exactly what is happening to the electron pairs and bonds in **step 1** of the mechanism above. [3]

- (b) Compound **F** can be prepared from propanal in a two-stage synthesis.

Compound **F** has the molecular formula $\text{C}_4\text{H}_8\text{O}_2$.

The proton NMR spectrum of compound **F** is shown below.

..... [1]

Explain your reasoning clearly. Refer to chemical shifts and splitting patterns in your answer.

..... [5]

$\text{CH}_3\text{CH}_2\text{CHO}$ $\longrightarrow$ compound E $\longrightarrow$ compound F

Deduce the identity of compound **E**.

Draw its displayed formula below.

[1]

[Total: 14]

[Turn over]

4 Benzene reacts with chlorine in the presence of a halogen carrier, such as AlCl_3 .

(a) (i) Write the equation for the reaction of benzene with chlorine.

[1]

(ii) How does the halogen carrier allow the reaction to take place?

.....
 [1]

(iii) Outline a mechanism for this reaction.

Include curly arrows and relevant dipoles.

[4]

(iv) State the name of this mechanism.

..... [1]

(b) In contrast to benzene, the reaction of an alkene with bromine does **not** need a halogen carrier.
 Compare the different reactivities of benzene and alkenes towards chlorine.

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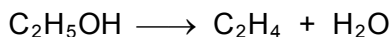
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..... [3]

[Total: 10]

- 5 Concentrated sulfuric acid reacts with many organic compounds, forming water as one of the products.

For example, sulfuric acid dehydrates ethanol by eliminating water to form ethene.



In each part below, sulfuric acid is a dehydrating agent.

- (a) Sulfuric acid dehydrates methanoic acid to form a gas, **G**, with the same molar mass as ethene.

Suggest the identity of **G** and write an equation for the reaction.

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

- (b) Sulfuric acid dehydrates sucrose, $\text{C}_{12}\text{H}_{22}\text{O}_{11}$, to form a black solid, **H**.

Suggest the identity of **H** and write an equation for the reaction.

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

- (c) Sulfuric acid dehydrates ethane-1,2-diol to form a compound **I** with a molar mass of 88 g mol^{-1} . In this reaction, two moles of ethane-1,2-diol produce one mole of **I** and two moles of H_2O .

Suggest the identity of **I**. Write an equation for the reaction and deduce the structural formula of compound **I**.

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..... [3]

[Total: 7]

Paper Total [60]

END OF QUESTION PAPER

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Sources

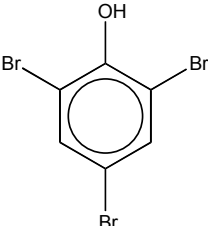
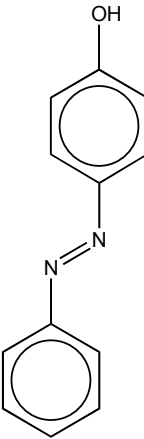
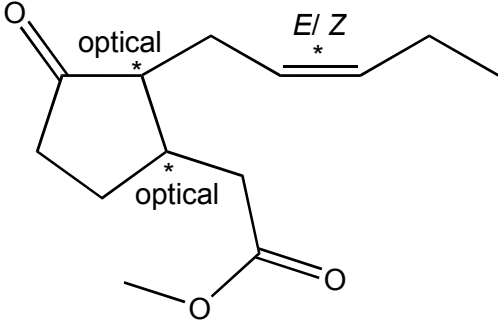
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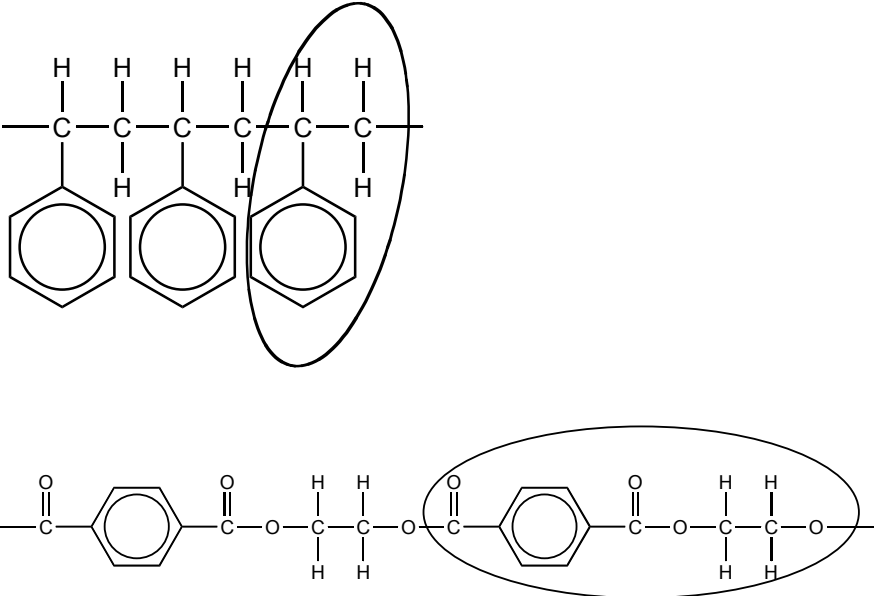
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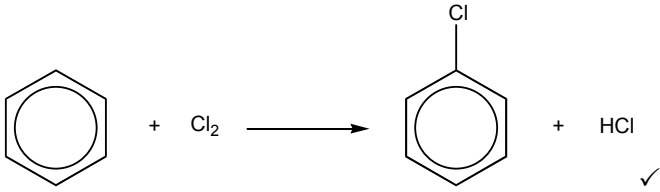
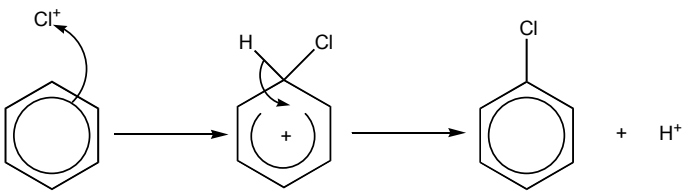
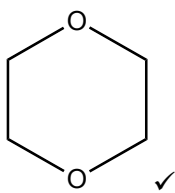
The maximum mark for this paper is **60**.

Question Number	Answer	Max Mark
1(a)(i)	CH_3COOH ✓	[1]
(ii)	$\text{C}_6\text{H}_5\text{NO}_2$ ✓	[1]
(iii)	$\text{CH}_3\text{CH}_2\text{CH}_2\text{NH}_2$ ✓	[1]
(iv)	CH_3COOH ✓ $\text{CH}_3\text{CH}_2\text{OH}$ ✓	[2]
(v)		[1]
(vi)	 diazo link ✓; rest of structure ✓	[2]
(b)(i)	$\text{C}_{13}\text{H}_{20}\text{O}_3$ ✓	[1]
(ii)	ketone ✓ ester ✓ alkene ✓	[3]
(iii)	 both optical ✓ E/Z ✓	[2]

Question Number	Answer	Max Mark
(iv)	possible side effects of other chiral compound ✓ increased costs/difficulty of separating of isomers ✓ using bacteria within synthetic route ✓	[2 max]
2(a)(i)	 1 mark for each repeat unit ✓✓	[2] (ii) 1 mark for each monomer ✓✓ [2] (b) C=O absorbs radiation/breaks ✓ ester linkage hydrolysed ✓ [2] (c)(i) one amide link shown correctly ✓ glycine and phenylalanine parts shown correctly ✓ proline linked correctly ✓ [3] (ii) 6✓ [1] (iii) gas/liquid chromatograph separates the tripeptides ✓ mass spectrometer produces a distinctive fragmentation pattern ✓ identification by computer using a spectral database ✓ [3]

Question Number	Answer	Max Mark
3(a)(i)	1 mark for each curly arrow ✓✓	[2]
(ii)		[1]
(iii)	electron pair donor ✓	[1]
(iv)	electron pair on H^- attracted to δ^+ carbon forming a dative covalent bond ✓ the double/ π electron pair breaks ✓ electron pair now on O^- ✓	[3]
(b)(i)	radio waves ✓	[1]
(ii)	chemical shift OCH_3 singlet from chemical shift at $\delta = 3.6$ ✓ $\text{CH}_2\text{C}=\text{O}$ from chemical shift at $\delta = 2.4$ ✓ <i>✎ requires use of 'chemical shift' and δ for 1st mark in this category</i> splitting/coupling CH_3 adjacent to CH_2 from triplet splitting pattern ✓ $\text{CH}_2\text{C}=\text{O}$ adjacent to CH_3 from quartet splitting pattern ✓ <i>✎ requires use of 'splitting/coupling' and triplet/quartet for 1st mark in this category</i> $\text{CH}_3\text{CH}_2\text{COOCH}_3$ ✓	[5]
(c)		[1]

[1]

4(a)(i)	 ✓	[1]
(ii)	Introduces a permanent dipole on Cl_2 / forms Cl^+ / $\text{AlCl}_3 + \text{Cl}_2 \rightarrow \text{AlCl}_4^- + \text{Cl}^+$ $\text{AlCl}_3 + \text{Cl}_2 \rightarrow \text{Cl}^{\delta+} - \text{AlCl}_3^{\delta-}$ ✓	[1]
(iii)	 correct dipole / Cl^+ ✓ curly arrow from benzene ring to Cl^+ / $\text{Cl}^{\delta+}$ ✓ intermediate ✓ curly arrow from H to regenerate benzene ring in intermediate ✓ H^+ as other product ✓	[4]
(iv)	electrophilic substitution ✓ with electrophile spelt correctly	[1]
(b)	In benzene, π electrons are delocalised/spread out ✓ In alkenes, π electrons are concentrated between 2 carbons ✓ Electrophiles attracted more to greater electron density in alkenes ✓	[3]
5 (a)	G: CO ✓ $\text{HCOOH}/\text{H}_2\text{CO}_2 \rightarrow \text{CO} + \text{H}_2\text{O}$ ✓ (b) H: C ✓ $\text{C}_{12}\text{H}_{22}\text{O}_{11} \rightarrow 12\text{C} + 11\text{H}_2\text{O}$ ✓ (c) I: $\text{C}_4\text{H}_8\text{O}_2$ ✓ $2\text{C}_2\text{H}_6\text{O}_2 \rightarrow \text{C}_4\text{H}_8\text{O}_2 + 2\text{H}_2\text{O}$ ✓ Structure:  ✓ accept any sensible structure of $\text{C}_4\text{H}_8\text{O}_2$	[7]
Paper Total		[60]

Assessment Objectives Grid (includes QWC)

Question	AO1	AO2	AO3	Total
1(a)(i)	1			1
1(a)(ii)	1			1
1(a)(iii)		1		1
1(a)(iv)		2		2
1(a)(v)	1			1
1(a)(iv)		2		2
1(b)(i)		1		1
1(b)(ii)		3		3
1(b)(iii)		2		2
1(b)(iv)	2			2
2(a)(i)	1	1		2
2(a)(ii)	2			2
2(b)		2		2
2(c)(i)		3		3
2(c)(ii)		1		1
2(c)(iii)	3			3
3(a)(i)		2		2
3(a)(ii)		1		1
3(a)(iii)	1			1
3(a)(iv)		3		3
3(b)(i)	1			1
3(b)(ii)			5	5
3(c)		1		1
4(a)(i)	1			1
4(a)(ii)	1			1
4(a)(iii)		4		4
4(a)(iv)	1			1
4(b)	3			3
5(a)		2		2
5(b)		2		2
5(c)		3		3
Totals	19	36	5	60