Advanced GCE Chemistry A

Unit F324 Rings, Polymers and Analysis – High banded Candidate Style Answer

Introduction

OCR has produced these candidate style answers to support teachers in interpreting the assessment criteria for the new GCE specifications and to bridge the gap between new specification release and availability of exemplar candidate work.

This content has been produced by senior OCR examiners, with the input of Chairs of Examiners, to illustrate how the sample assessment questions might be answered and provide some commentary on what factors contribute to an overall grading. The candidate style answers are not written in a way that is intended to replicate student work but to demonstrate what a “medium” or “high” response might include, supported by examiner commentary and conclusions.

As these responses have not been through full moderation and do not replicate student work, they have not been graded and are instead, banded “medium” or “high” to give an indication of the level of each response.

Please note that this resource is provided for advice and guidance only and does not in any way constitute an indication of grade boundaries or endorsed answers.

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

(i) CH_3CHO **[1]**

Candidate style answer	*Examiner's commentary*
CH3COOH	

(ii) C_6H_6 $\xrightarrow[\text{and conc. } HNO_3\text{, heat}]{\text{conc. } H_2SO_4}$ **[1]**

Candidate style answer	*Examiner's commentary*
$C_6H_5NO_2$	

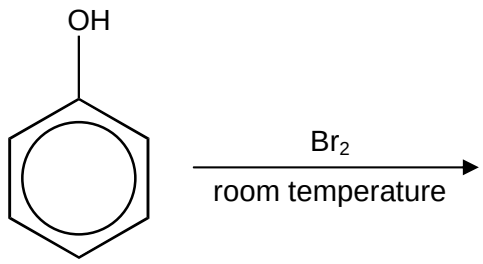
(iii) $CH_3CH_2CH_2Br$ $\xrightarrow[\text{heat}]{\text{excess ethanolic } NH_3}$ **[1]**

Candidate style answer	*Examiner's commentary*
$CH_3CH_2CH_2NH_2$	

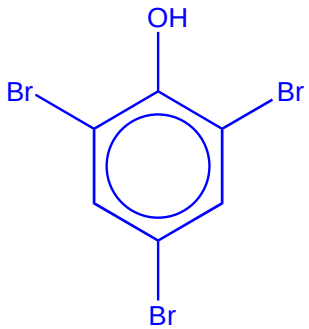
(iv) $CH_3CH_2CH_2Br$ $\xrightarrow[\text{heat}]{HCl(aq)}$ **[2]**

Candidate style answer	*Examiner's commentary*
CH_3COOH + CH_3CH_2OH	

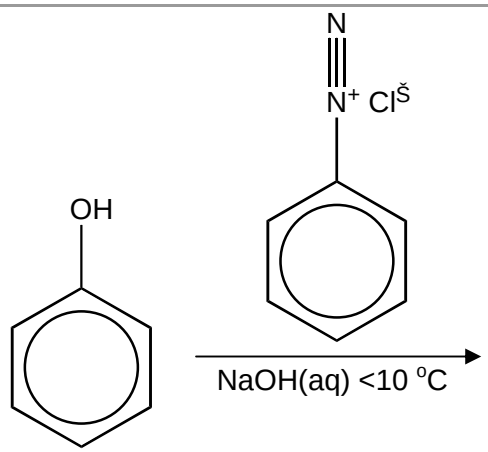
(v)



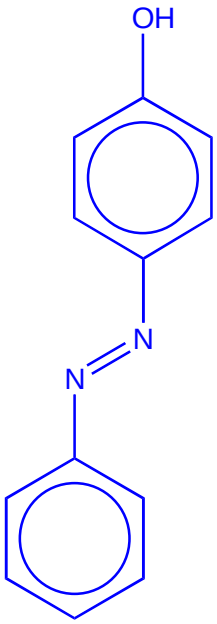
[1]

Candidate style answer	*Examiner's commentary*
	

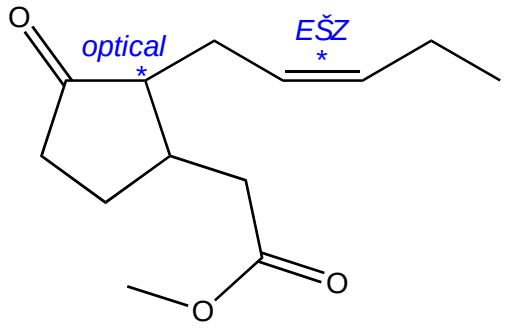
(vi)



[2]

Candidate style answer	*Examiner's commentary*
	Part **(a)** tests chemistry from many different functional groups. The answers are perfect and the candidate has clearly prepared well for the exam by learning the reagents and conditions for many reactions studied in the course

1(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]**

Candidate style answer	*Examiner's commentary*
$C_{13}H_{20}O_3$	

(ii) Compound A contains several functional groups.
Identify, by name, the functional groups in compound A.
[3]

Candidate style answer	*Examiner's commentary*
ketone, ester and alkene	

(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]

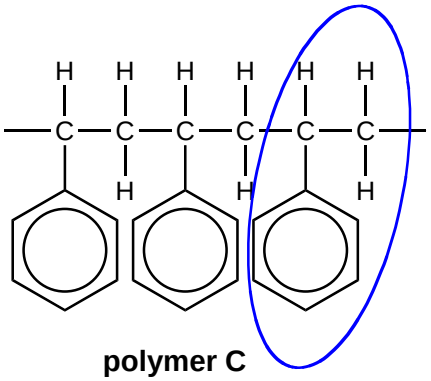
Candidate style answer	*Examiner's commentary*
See diagram above.	

(iv) Outline two important factors that pharmaceutical companies need to consider when manufacturing chiral compounds for use as medicines.
[2]

Candidate style answer	*Examiner's commentary*
The other chiral compound could have side effects such as thalidomide. It is difficult and expensive to separate optical isomers.	Questions often use a complex molecule to assess understanding of basic concepts in organic chemistry. The responses here are good throughout, although only one of the two chiral carbon atoms has been identified in (**iii**).

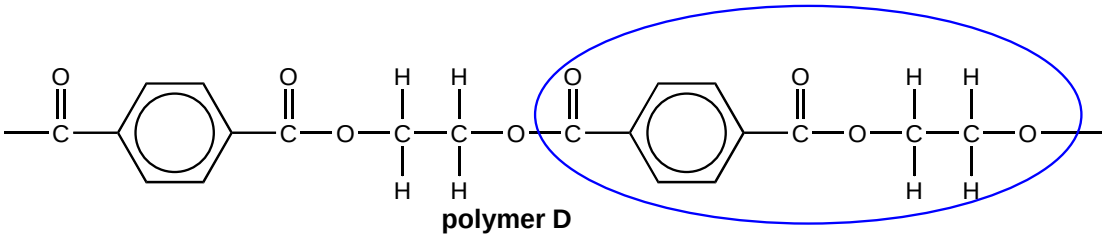
[Total 16]

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



polymer C

Candidate style answer	*Examiner's commentary*
`See diagram above.`	



polymer D

2

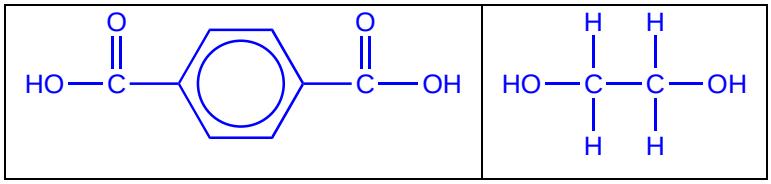
(a)(i) Circle, on the diagrams above, the simplest repeat unit in each polymer.

[2]

Candidate style answer	*Examiner's commentary*
`See diagram above.`	

(ii) In the boxes below, draw the displayed formulae of the two monomers that could be used to prepare polymer D.

[2]

Candidate style answer	*Examiner's commentary*
	Standard bookwork and again, the candidate can be rewarded for careful preparation. Repeat units are always likely to be asked on this exam. The question would have been more testing if based on unfamiliar polymers.

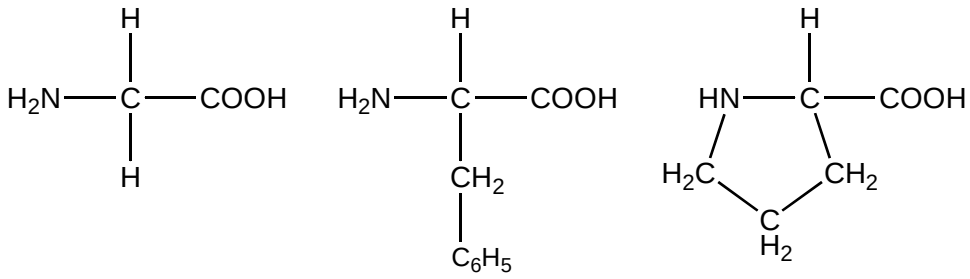
(b) Chemists have developed degradable polymers to reduce the quantity of plastic waste being disposed off in landfill sites. Polymer D is more likely to be a 'degradable polymer' than polymer C.

Suggest two reasons why.

[2]

Candidate style answer	*Examiner's commentary*
The ester group in D has a C=O bond which absorbs radiation and gets broken.	A reasonable attempt but no mention of hydrolysis.

2(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.

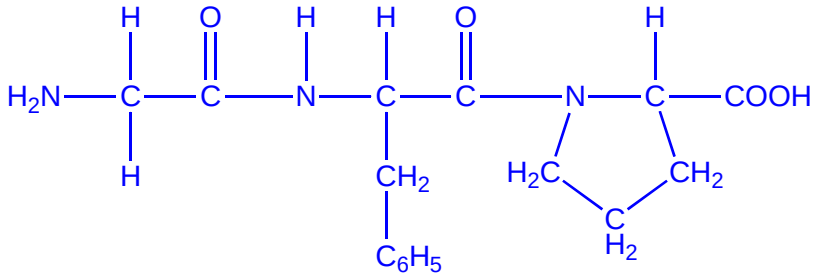


glycine **phenylalanine** **proline**

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]

Candidate style answer	*Examiner's commentary*
	

(ii) How many different tripetides could have been formed containing glycine, phenylanine and proline?

[1]

Candidate style answer	*Examiner's commentary*
3	

(iii) The mixture of tripeptides can be analysed by using gas chromatography, coupled with mass spectrometry.
Summarise how each method contributes to the analysis.

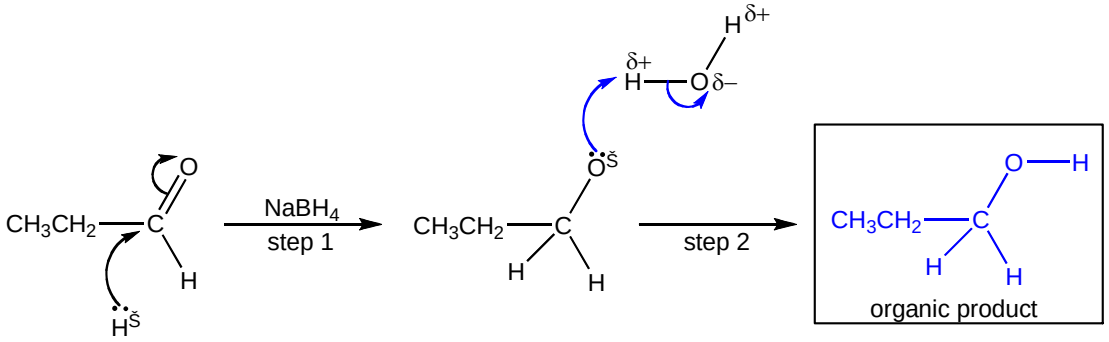
[3]

Candidate style answer	*Examiner's commentary*
Gas chromatography separates the mixture. The mass spectrometer produces fragments that allow the compound to be identified by comparing with a spectra database on a computer.	A difficult question in which to score all the marks. Many candidates will be able to assemble the amino acids in the correct order with a correct peptide bonds between glycine and phenylalanine. This candidate has done extremely well to attach correctly the secondary N atom in proline. Unfortunately the candidate has not considered all combinations of the amino acids in **(ii)**. The final part is standard bookwork and has been well learnt.

[Total: 13]

3 **Propanal, CH_3CH_2CHO, can be used in the synthesis of organic compounds.**

(a) **CH_3CH_2CHO 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 <u>step 2.</u>**

[2]

Candidate style answer	*Examiner's commentary*
See diagram above.	

(ii) **Draw the structure of the organic product in the box above.**

[1]

Candidate style answer	*Examiner's commentary*
See diagram above.	

(iii) **What is meant by the term *nucleophile*?**

[1]

Candidate style answer	*Examiner's commentary*
A nucleophile is a lone pair donor.	

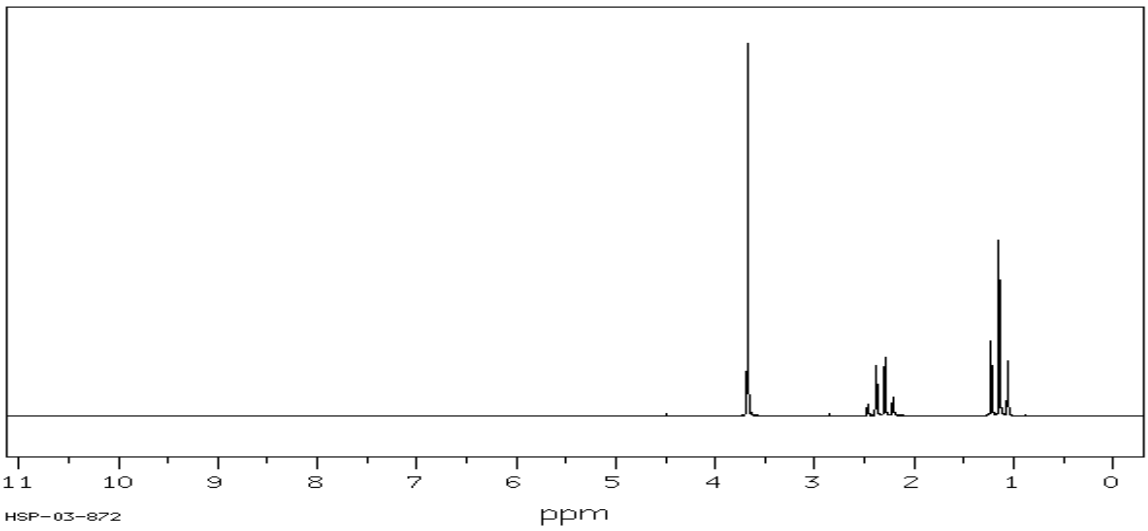
(iv) **Describe, in words, exactly what is happening to the electron pairs and bonds in step 1 of the mechanism above.**

[3]

Candidate style answer	*Examiner's commentary*
The lone pair on the H^- gets attracted to the positive carbon atom forming a bond. The double bond breaks and the electron pair is now on the oxygen atom	Mechanisms will always be tested on this paper. Candidates aiming for a high grade must learnt the stock mechanisms studied at A2: electrophilic substitution and nucleophilic addition. The candidate has obviously learnt this mechanism and the curly arrows have been shown exactly with precision. The definition in **(iii)** is careless and should have stated that an electrophile is an electron pair donor as a multiple bond can also act as nucleophile. Although mechanisms can be memorised, it is much more difficult to explain what is happening and the candidate's response in **(iv)** lacks some important detail; also the carbon atom has a $\delta+$ partial charge only. The candidate also did not communicate that just one bond of the double bond breaks.

(b) Compound F can be prepared from propanal in a two-stage synthesis.
Compound F has the molecular formula of $C_4H_8O_2$.

The NMR spectrum of compound F is shown below.



(i) What region of the electromagnetic spectrum is used in NMR spectroscopy?

[1]

Candidate style answer	*Examiner's commentary*
Radio waves	

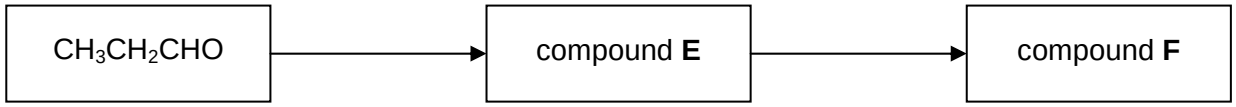
(ii) Analyse and interpret the NMR spectrum of compound F to identify its structure. Explain your reasoning clearly. Refer to chemical shifts and splitting patterns in your answer.

In your answer, you should use appropriate technical terms, spelt correctly.

[5]

Candidate style answer	*Examiner's commentary*
The CH_3 at 1.2 is split by the adjacent CH_2 group. This makes a triplet. The CH_2 is split by the CH_3 into four. The OCH_3 at 3.6 is just a single peak as there are no protons on any adjacent carbon atoms. The CH_2 at 2.4 must be next to a C=O . So compound F must be $CH_3CH_2COOCH_3$.	

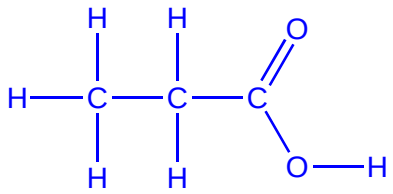
(c) The flowchart below represents the two-stage synthesis of compound F from propanal.



Deduce the identity of compound E.

Draw its displayed formula below.

[1]

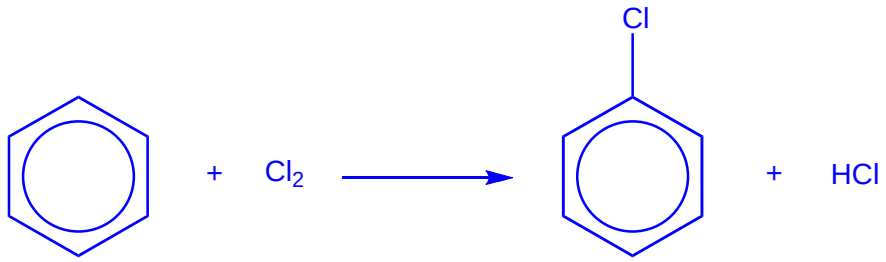
Candidate style answer	*Examiner's commentary*
	The candidate clearly has a good understanding of H-NMR spectroscopy and has both identified the key features in the spectrum and correctly identified the unknown compound. Both splitting and chemical shifts have been referred to. It is a pity that the candidate's technical language is weak. There is no mention of 'chemical shift' or 'δ values'. Although 'triplet is mentioned, there is no mention of 'singlet' or 'quartet', nor any explanation of the splitting by the *n* + 1 rule.

[Total: 14]

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]

Candidate style answer	*Examiner's commentary*
	

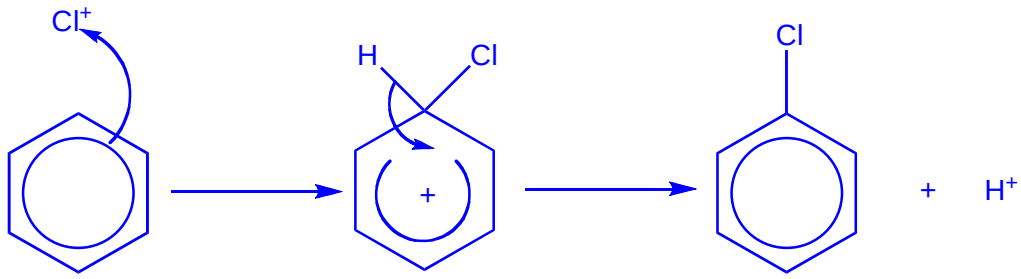
(ii) How does the halogen carrier allow the reaction to take place?

[1]

Candidate style answer	*Examiner's commentary*
`AlCl3 is used to induce a dipole in the chlorine to form Cl+`	

(iii) Outline a mechanism for this reaction.
Include curly arrows and relevant dipoles.

[4]

Candidate style answer	*Examiner's commentary*
	

(iv) State the name of this mechanism.

[1]

Candidate style answer	*Examiner's commentary*
`Electrophilic substitution`	

(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.

[3]

Candidate style answer	*Examiner's commentary*
In benzene, the pi electrons are delocalised. In alkenes, the pi electrons are concentrated between 2 carbons and there is more electron density. This means that bromine gets attracted more to the greater electron density in alkenes.	Another excellent mechanism with a clear description of the role of the halogen carrier. The comparison in the reactivities of benzene and alkenes with bromine is rather sparse but is just about adequate to secure the marks.

[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 ethane.

$$C_2H_5OH \longrightarrow C_2H_4 + H_2O$$

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]

Candidate style answer	*Examiner's commentary*
G is CO because both have a relative molecular mass of 28. $HCOOH \longrightarrow CO + H_2O$	

(b) **Sulfuric acid dehydrates sucrose, $C_{12}H_{22}O_{11}$, to form a black solid, H.**

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

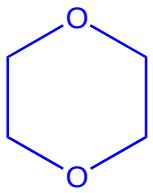
[2]

Candidate style answer	*Examiner's commentary*
H is carbon because of the black colour $C_{12}H_{22}O_{11} \longrightarrow 12C + 11H_2O$	

(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.

[3]

Candidate style answer	*Examiner's commentary*
I is $C_4H_8O_2$ $2C_2H_6O_2 \longrightarrow C_4H_8O_2 + 2H_2O$ The structure is an ester, perhaps $CH_3CH_2COOCH_3$	The candidate's responses are very competent as the question is set in an unfamiliar context. To secure a high grade, candidates must be able to tackle such problems as well as the straight recall questions. This candidate has secured most of the available marks, slipping up just in the very difficult last part which required the structure below. 

[Total: 7]

Overall Banding High

To secure a high mark, the organic chemistry certainly has to be learnt. Without adequate preparation, marks for mechanisms and standard bookwork recall will get frittered away. But candidates will also need to be able to apply their knowledge and understanding in questions that introduce unfamiliar structures or new reactions.

Overall the candidate's responses are of a high standard.

[Total: 60]