Advanced GCE Chemistry A

Unit F324 Rings, Polymers and Analysis – Medium 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*
CH_3CH_2COOH	

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

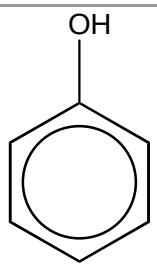
[1]

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

(iv) $CH_3COOCH_2CH_3$ $\xrightarrow[\text{heat}]{\text{HCl(aq)}}$

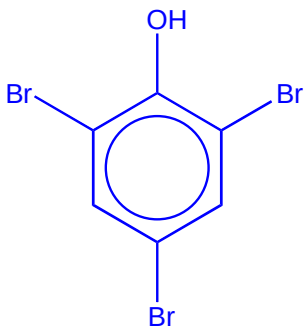
[2]

Candidate style answer	*Examiner's commentary*
$CH_3COCl + CH_3CH_2OH$	

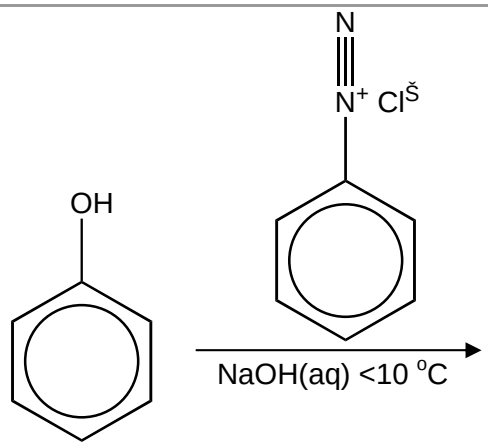
(v) 

$\xrightarrow[\text{room temperature}]{Br_2}$

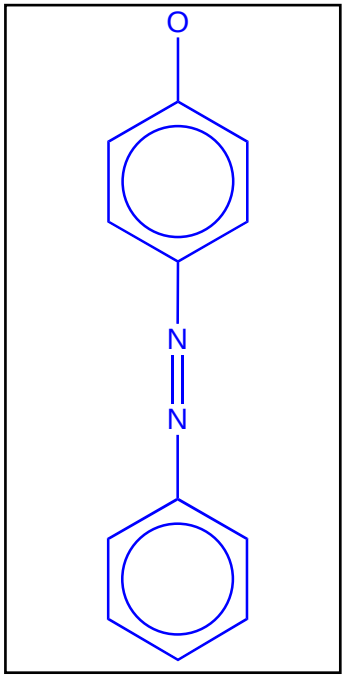
[1]

Candidate style answer	*Examiner's commentary*
	

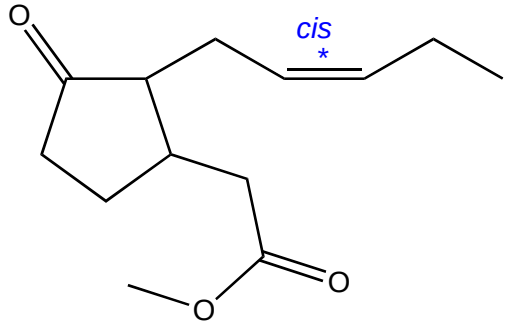
(vi)



[2]

Candidate style answer	*Examiner's commentary*
	These are mixed responses showing that the candidate has learnt some content but has patchy knowledge of other parts of the specification. There is a careless mistake in **(i)** with the carbon chain shown as the wrong length. In part **(iii)**, the candidate makes the mistake of thinking that the Cl in HCl is part of the reaction. A competent attempt is made in **(v)** with a correct diazo link but it is spoilt by missing an H from the O atom.

(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*
$C_{13}H_{18}O_3$	

(ii) **Compound <u>A</u> contains several functional groups.**

Identify, by <u>name</u>, the functional groups in compound A.

[3]

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

(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.	

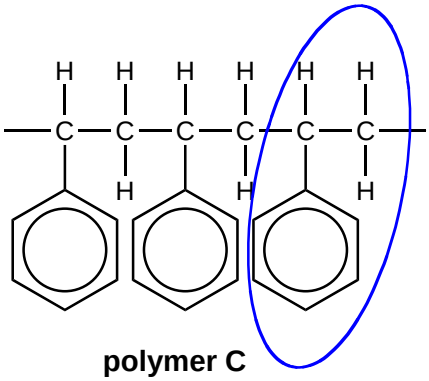
(iv) Outline two important factors that pharmaceutical companies need to consider when manufacturing chiral compounds for use as medicines.

[2]

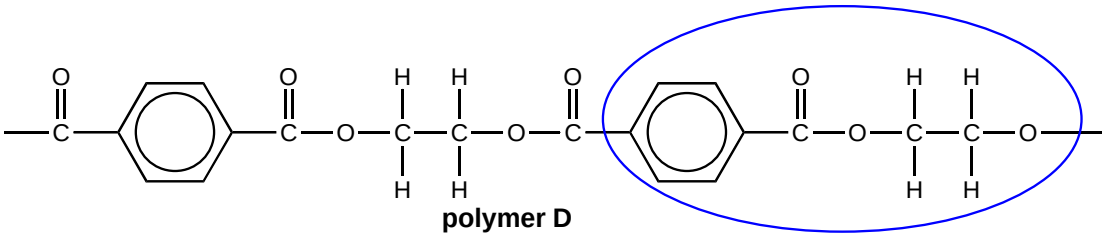
Candidate style answer	*Examiner's commentary*
There are often side effects in the other isomer like in thalidomide.	Questions often use a complex molecule to assess understanding of basic concepts in organic chemistry. The responses here are mixed, showing that the candidate doesn't understand some key points. In the molecular formula, two hydrogen atoms have been missed, probably those at the carbon atoms bonded to three other carbon atoms. There is poor exam technique in **(ii)**: as names were asked for, C=C would not score. In **(iii)**, the candidate has completely missed the optical isomerism. With 2 marks being available, the candidate should have realised that more was required. In **(iv)**, the candidate could recall thalidomide but there is little else. This part was not difficult but the specification content had not been learnt.

[Total: 16]

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



polymer C



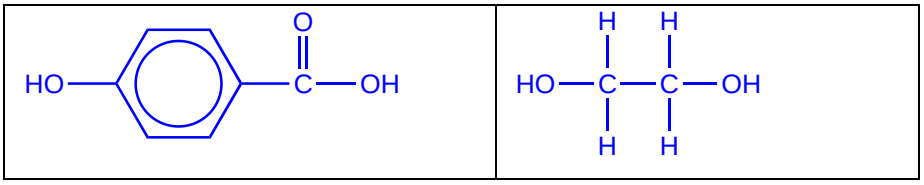
polymer D

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

[2]

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*
See diagram above.	Standard bookwork but the candidate has again suffered from poor preparation. The repeat group in polymer D has missed a C=O and this has led to an error in one of the repeat units. The candidate could have used the section of the polymer shown in the question to check whether their response was realistic.

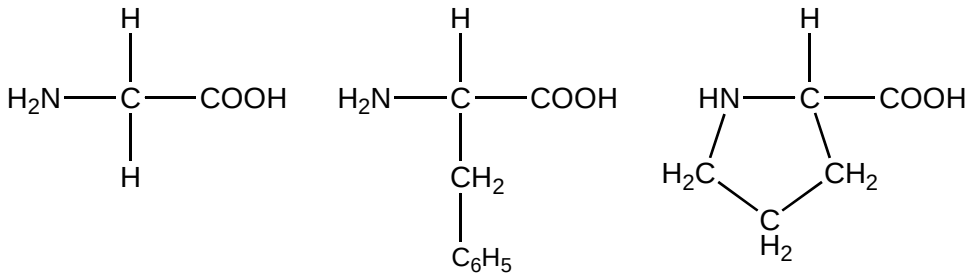
(b) Chemists have developed degradable polymers to reduce the quantity of plastic waste being disposed off in landfill sites. Polymer **D** is more likely to be a 'degradable polymer' than polymer **C**.

Suggest **two** reasons why.

[2]

Candidate style answer	*Examiner's commentary*
The ester group in D degrades	The candidate has no idea! Again, the material has not been learnt.

(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.**

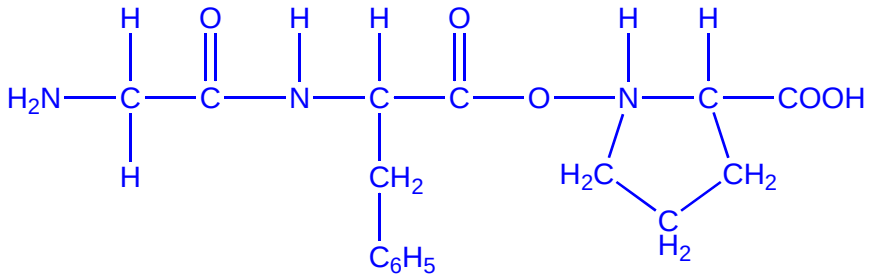


glycine **phenylalanine** **proline**

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*
20	

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

Summarise how each method contributes to the analysis.

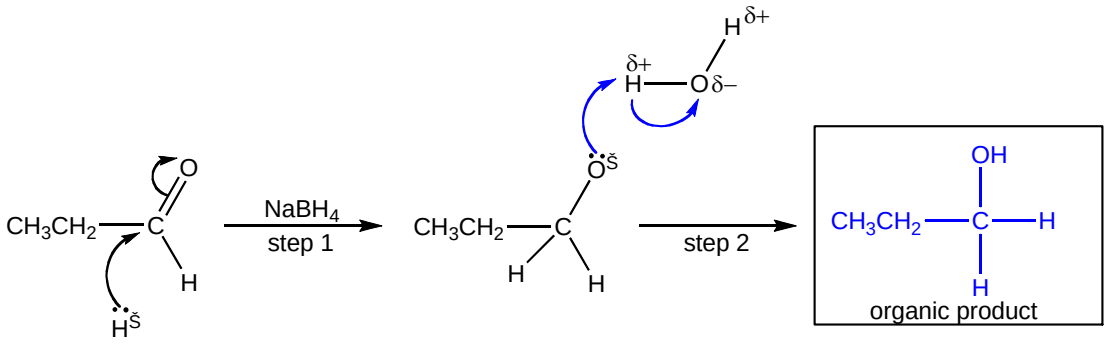
[3]

Candidate style answer	*Examiner's commentary*
Gas chromatography separates the tripeptides. The mass spectrometer alanyses and then a database is used to identify the components.	The candidate managed successfully to combine glycine with phenylalanine. In attempting to connect proline, the candidate made the common mistake of finishing up with a COON connection. The candidate then seemed to rely upon the conventional amino acid general formula for attaching proline. The candidate should have realised that this response is incorrect as the nitrogen atom is shown with 4, rather than 3, bonds. In **(ii)**, the candidate had no idea and seemed to just guess. The response in **(iii)** contained the key features of GC-MS. (Pity about the spelling.)

[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 step 2. [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]

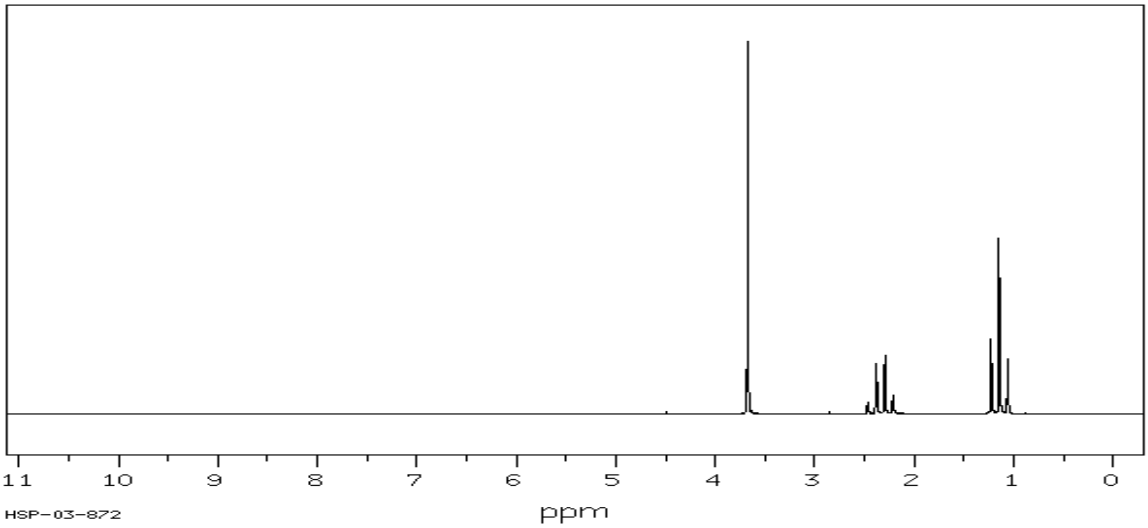
Candidate style answer	*Examiner's commentary*
A nucleophile loves the nucleus	

(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 electron pairs get attracted and form bonds. Bonds get broken as well. A curly arrow shows how electron pairs move.	In **(i)**, the candidate has obviously tried to learn this mechanism and has shown the curly arrows from the organic intermediate with precision. Unfortunately, the second curly arrow is imprecise and should have been shown starting from the H–O bond. The definition in **(iii)** is poor and seems to have been made up. This has not been learnt. The response to **(iv)** reinforces that the candidate does not understand what happens to electron pairs and bonds during a mechanism. Despite this, the final statement shows some recall that has stuck, even if it has not been applied.

(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	

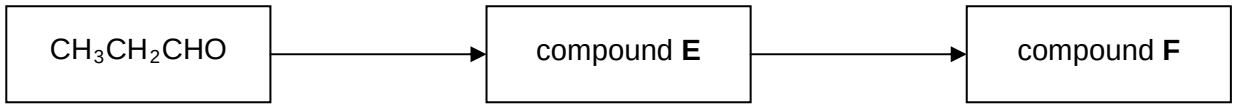
(ii) Analyse and interpret the NMR spectrum of compound F to identify its structure. Explain your reasoning clearly. Refer to chemical shifts and splitting patterns in your answer.

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

[5]

Candidate style answer	*Examiner's commentary*
There are three peaks so there are three types of proton. The quartet and a triplet means that there is a CH_2CH_3. The other peak must be another CH_3. *Because it's $C_4H_8O_2$, it must be $CH_3COOCH_2CH_3$*	

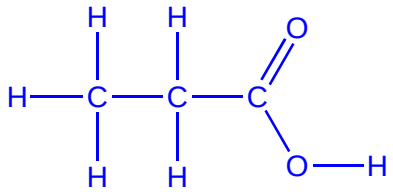
(c) The flowchart below represents the two-stage synthesis of compound F from propanal.



Deduce the identity of compound E.

Draw its displayed formula below.

[1]

Candidate style answer	*Examiner's commentary*
	The candidate has some idea of how to interpret a H-NMR spectrum and has identified correctly the relevance of the triplet/quartet splitting combination. Unfortunately the pointer in the question to refer to chemical shifts has been ignored completely. The suggested structure for the unknown compound is a competent attempt based on the candidates partial analysis. However, the candidate has shown the ester the 'wrong way around', an error that would not have been made had chemical shifts been considered. The candidate has then correctly shown the structure for F in part **(c)**. Had the candidate compared this structure to their answer to **(b)**, they would have seen that something was wrong with their H-NMR analysis.

[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*
$C_6H_6 + Cl_2 \longrightarrow C_6H_5Cl + HCl$	

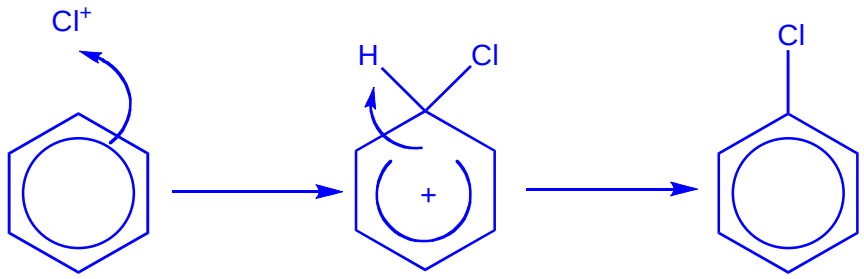
(ii) How does the halogen carrier allow the reaction to take place?

[1]

Candidate style answer	*Examiner's commentary*
It carries the halogen	

(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	A correct equation in **(i)** followed by what is clearly a guess in **(ii)** (another easy recall mark). The attempted mechanism in part **(iii)** shows some understanding, as the first curly arrow and the intermediate are shown correctly. The second curly arrow is the wrong way around and rather non-committal. The candidate has also missed out the H^+ as the product if the second step. This is a stock mechanism that delivers easy marks, if learnt.

(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 electrons are delocalised. In alkenes, the electrons aren't delocalised because there's a double bond. Alkenes are more reactive because of the double bond.	The comparison in the reactivities of benzene and alkenes with bromine is sparse, the candidate seeming to just remember that benzene has delocalised electrons. The second sentence is simply the reverse statement of the first and the third sentence and repeats information given in the question. Examination questions often ask candidates to compare the reactivity of bromine with benzene, alkenes and phenols. This is another example of knowledge and understanding that needs to be learnt.

[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 carbon monoxide. $HCOOH \longrightarrow CO + H_2O$	

(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.

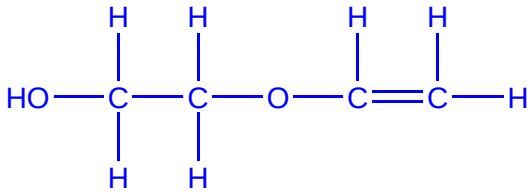
[2]

Candidate style answer	*Examiner's commentary*
H is $C_{12}H_{20}O_{10}$ *because water has been lost* $C_{12}H_{22}O_{11} \longrightarrow C_{12}H_{20}O_{10} + H_2O$	

(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 $C_4H_8O_2$ $2C_2H_6O_2 \longrightarrow C_4H_8O_2 + H_2O$ *The structure is below:* 	Compared with some of the recall responses earlier in the paper, the responses here show that the candidate can apply their chemistry to an unfamiliar situation. There are flashes of inspiration that suggest that the candidate could do well with more application of their ability. The response to **(a)** is completely correct. In **(b)**, the candidate has not linked the clue that a 'black solid' has been formed with carbon as a product. Despite this, water has been removed from the starting material and the equation makes sense from what the candidate thought was happening, so some credit can be awarded. Part **(c)** is difficult but again the candidate has analysed the information to arrive at the correct molecular formula. From there, however, the candidate is clutching at straws. Water is removed but the reference in the question to 2 moles has been ignored. The equation and proposed structure are brave attempts but unfortunately completely wrong. The candidate would have had more chance of success by using all the information in the question.

[Total: 7]

Overall banding Medium

The responses from this candidate echo those of many. Organic chemistry must be learnt and, with this learning, the understanding will come. This candidate was poorly prepared and frittered many marks away. There are some intuitive responses that suggest that there is some hidden potential sealed up that can be released with a better knowledge base.

There were also instances in which the candidate had ignored some of the information supplied in the question. Information is usually supplied for a reason and perhaps the candidate could have marked off data as it had been used so as to highlight what remained.

[Total: 60]