OCR
Oxford Cambridge and RSA

Wednesday 10 June 2015 – Afternoon

A2 GCE CHEMISTRY A

F324/01 Rings, Polymers and Analysis

Candidates answer on the Question Paper.

OCR supplied materials:
- *Data Sheet for Chemistry A* (inserted)

Other materials required:
- Scientific calculator

Duration: 1 hour 15 minutes

* F 3 2 4 0 1 *

* 4 9 8 9 3 3 7 5 1 9 *

Candidate forename		Candidate surname	

Centre number						Candidate number				

INSTRUCTIONS TO CANDIDATES

- The Insert will be found inside this document.
- Write your name, centre number and candidate number in the boxes above. Please write clearly and in capital letters.
- Use black ink. HB pencil may be used for graphs and diagrams only.
- Answer **all** the questions.
- Read each question carefully. Make sure you know what you have to do before starting your answer.
- Write your answer to each question in the space provided. If additional space is required, you should use the lined pages at the end of this booklet. The question number(s) must be clearly shown.
- Do **not** write in the bar codes.

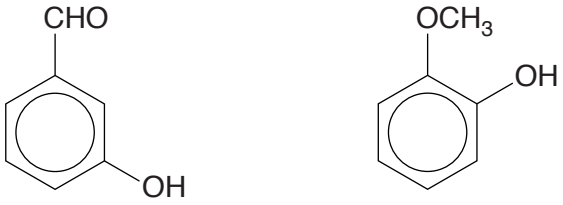
INFORMATION FOR CANDIDATES

- The number of marks is given in brackets **[ ]** at the end of each question or part question.
- Where you see this icon you will be awarded marks for the quality of written communication in your answer.
  This means, for example, you should:
  - ensure that text is legible and that spelling, punctuation and grammar are accurate so that meaning is clear;
  - organise information clearly and coherently, using specialist vocabulary when appropriate.
- You may use a scientific calculator.
- A copy of the *Data Sheet for Chemistry A* 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**.
- This document consists of **20** pages. Any blank pages are indicated.

Answer **all** the questions.

1 A student analysed a mixture of compounds found in red wine using gas chromatography followed by mass spectrometry (GC-MS).

Two of the compounds found to be present in the mixture are shown below.



compound A **compound B**

(a) The column in the gas chromatogram is packed with solid beads coated with a liquid polymer.

How does gas chromatography (GC) separate the compounds in the mixture?

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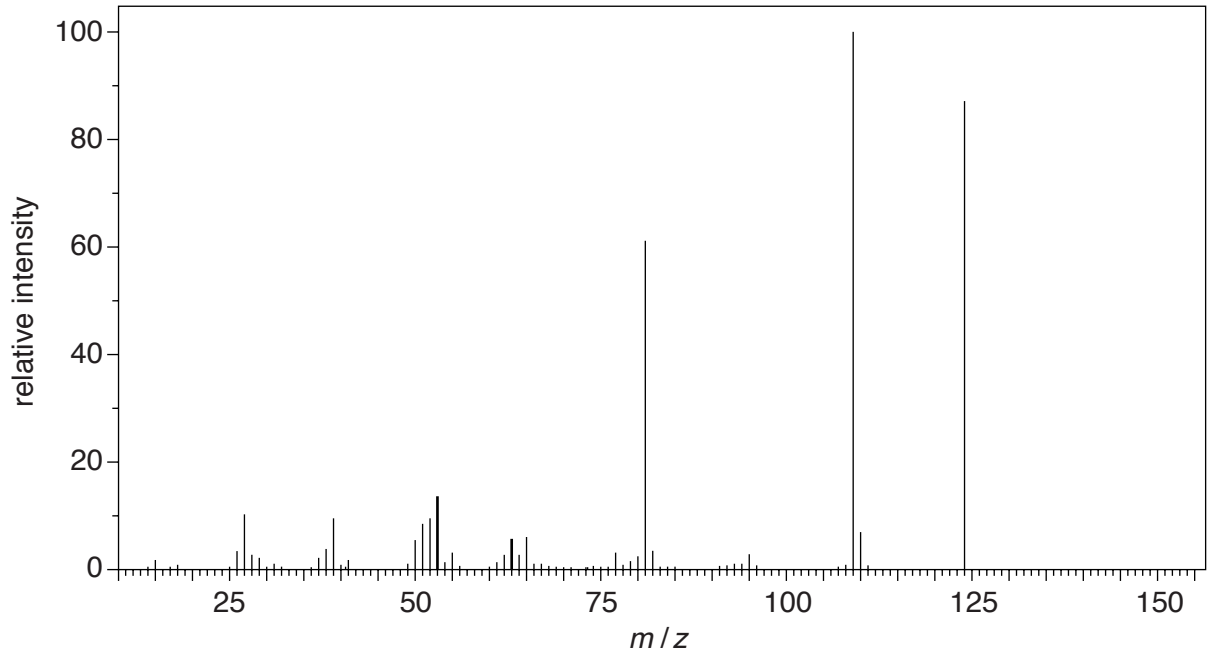
..... **[1]**

(b) The mass spectrum (MS) of the **first** compound to emerge from the column is shown below.



(i) Identify the compound responsible for this spectrum.

Give a reason for your answer.

.....

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

(ii) What does your answer to **(b)(i)** suggest about the interaction of this compound with the phases present in the column?

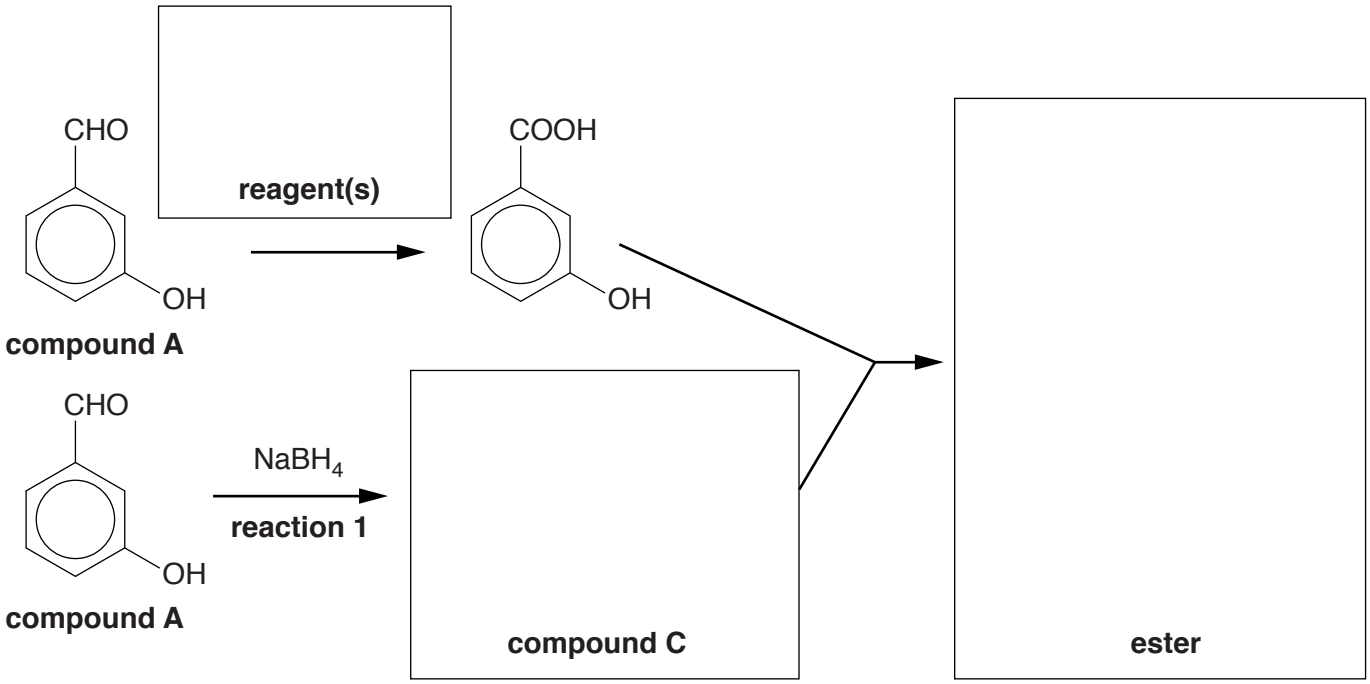
.....

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

(c) In red wine, compound **A** slowly forms an ester.

The formation of the ester can also be done in the laboratory, as shown in the flowchart below. Separate portions of compound **A** are used in the formation of the ester.

(i) Complete the boxes in the flowchart below.

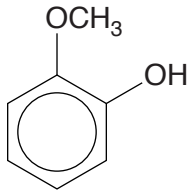


[3]

(ii) Give the mechanism to show the formation of compound **C** in **reaction 1**.
Use curly arrows and relevant dipoles.

[3]

(d) 1 mol of compound **B** reacts with 2 mol of bromine, Br_2 by electrophilic substitution.



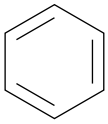
compound B

Write a balanced equation for this reaction, showing clearly the structure of the organic compound.

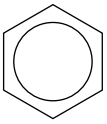
[1]

[Total: 10]

2 Chemists often use two different structures to represent a molecule of benzene, as shown below.



structure A



structure B

(a) (i) Describe, with the aid of suitable diagrams showing orbital overlap, the difference in bonding between structure **A** and structure **B**.

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

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..... **[4]**

(ii) The table below shows the enthalpy changes for the reactions of cyclohexene, C_6H_{10}, and benzene, C_6H_6, with hydrogen.

reaction	enthalpy change / kJ mol^{-1}
$C_6H_{10} + H_2 \rightarrow C_6H_{12}$	–119
$C_6H_6 + 3H_2 \rightarrow C_6H_{12}$	–208

Using this information, suggest and explain whether structure **A** or structure **B** is a better representation of benzene.

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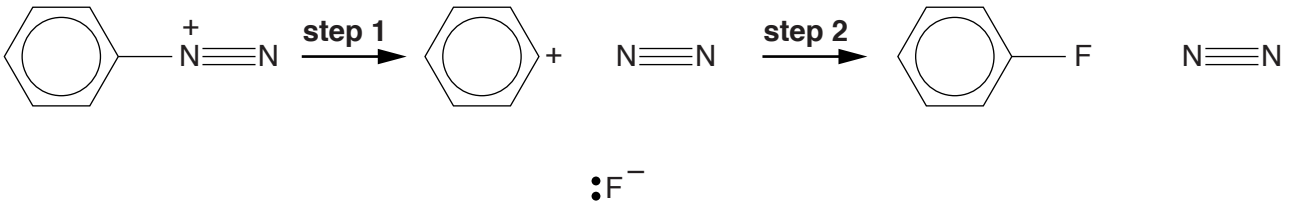
..... **[2]**

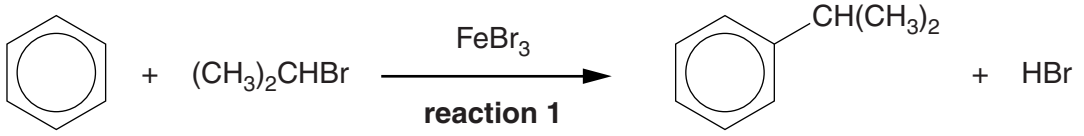
(b) Benzene compounds can undergo nucleophilic substitution reactions.

Add curly arrows to the diagram below to show the two-step mechanism of $C_6H_5N_2^+$ with F^-.



[2]

(c) Benzene can react with halogenoalkanes in the same way as with bromine, as shown in **reaction 1** below.

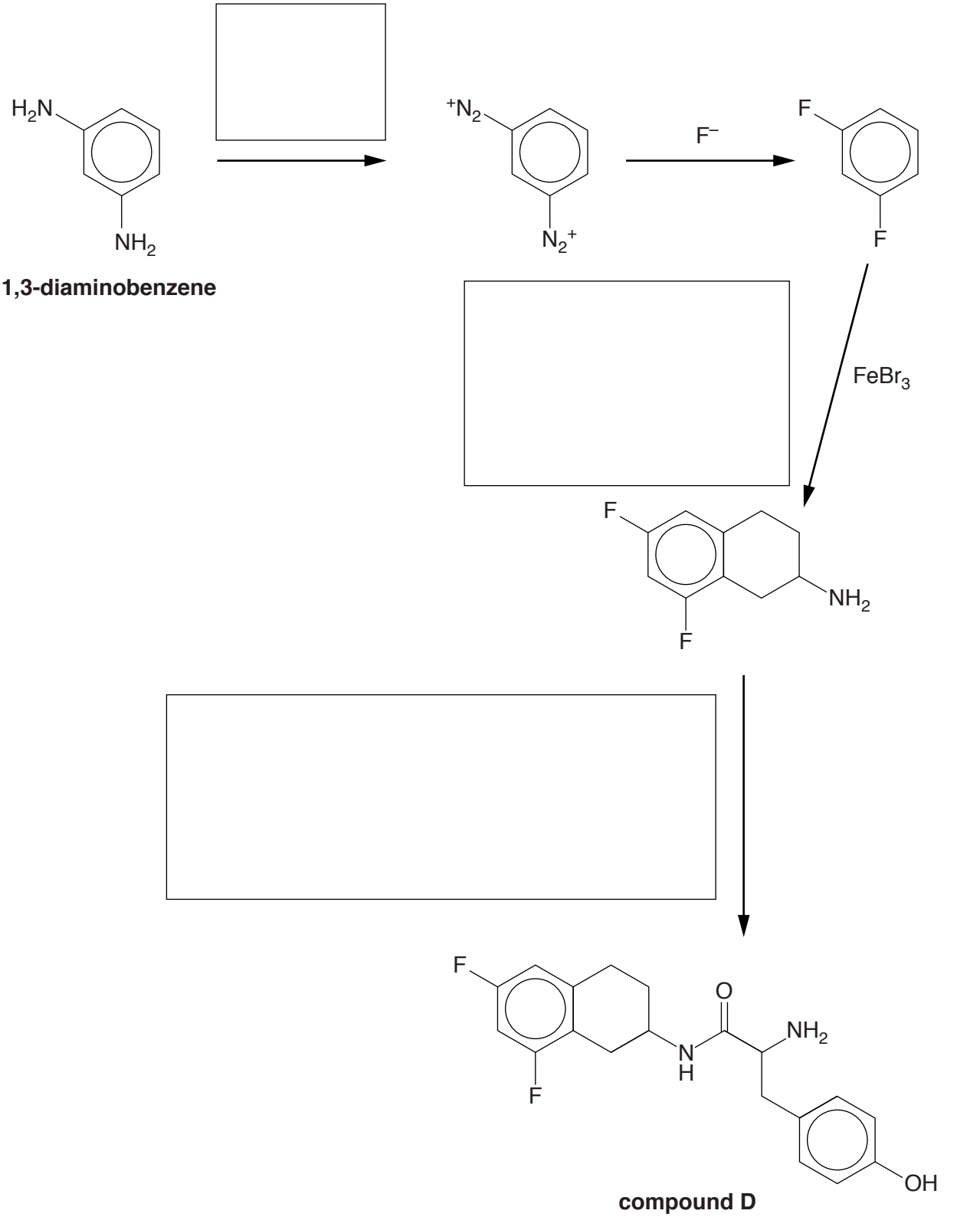


Write an equation to show the formation of the electrophile that reacts with benzene in **reaction 1**.

[1]

(d) The types of reaction in **(b)** and **(c)** can be used to synthesise compound **D**, as shown in the flowchart below.

(i) Complete the boxes below to suggest formulae for the reactants involved in the synthesis of compound **D**.
Give structures for organic compounds.

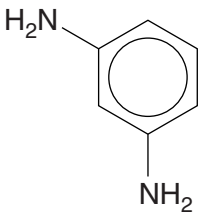


1,3-diaminobenzene

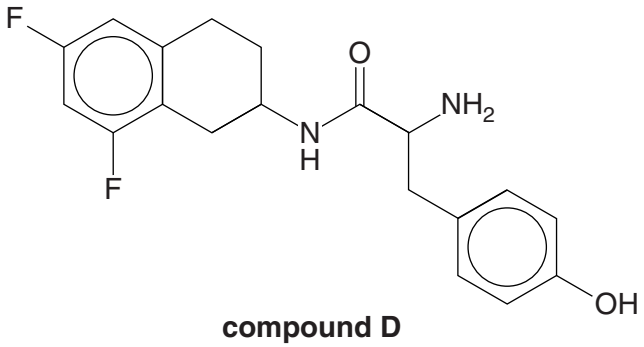
compound D

[3]

(ii) In a synthesis of compound **D** from 1,3-diaminobenzene shown in the flowchart, 1.73 g of compound **D** was prepared. These structures have been repeated below:



1,3-diaminobenzene



compound D

The overall percentage yield of compound **D** was 40.0%.

M_r of compound **D** = 346.0

Calculate the mass of 1,3-diaminobenzene needed for this synthesis.

mass = ... g **[3]**

(iii) Compound **D** has been developed for possible use as a drug to treat heart conditions. When compound **D**, prepared in this synthesis, was given to patients, only 25% of the dose was effective in treating their heart conditions.

Explain why only 25% of the dose was effective. Suggest how the synthesis of compound **D** might be changed to make the dose more effective.

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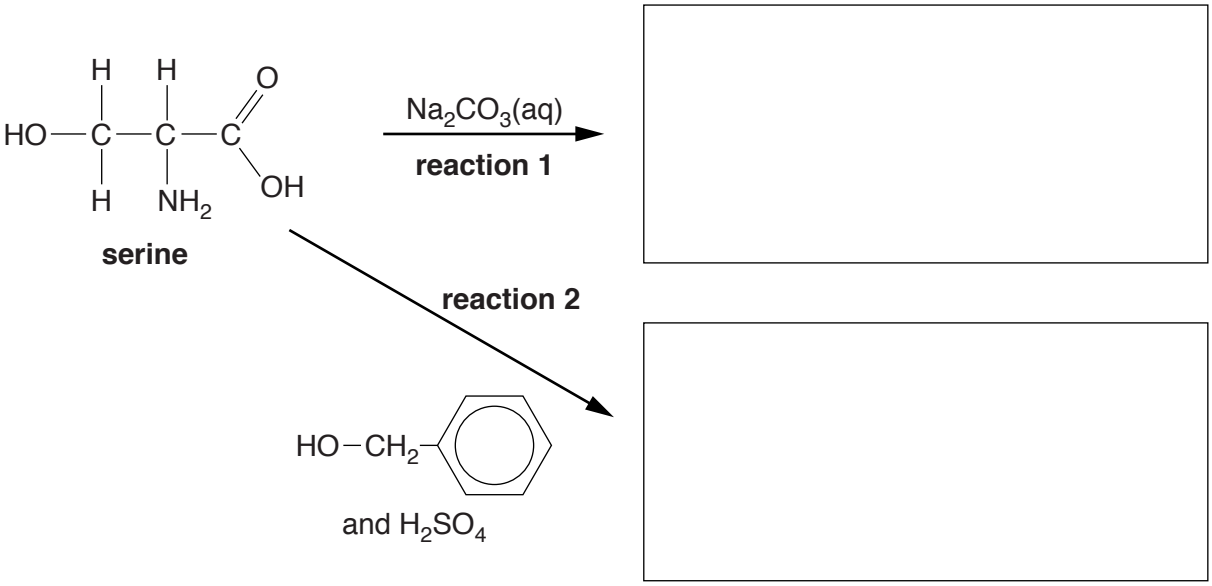
..... **[3]**

[Total: 18]

3 Many α-amino acids have several functional groups.

(a) Serine, shown below, is a naturally occurring α-amino acid.

(i) In the boxes below, draw the structure of the organic compounds formed by each reaction.



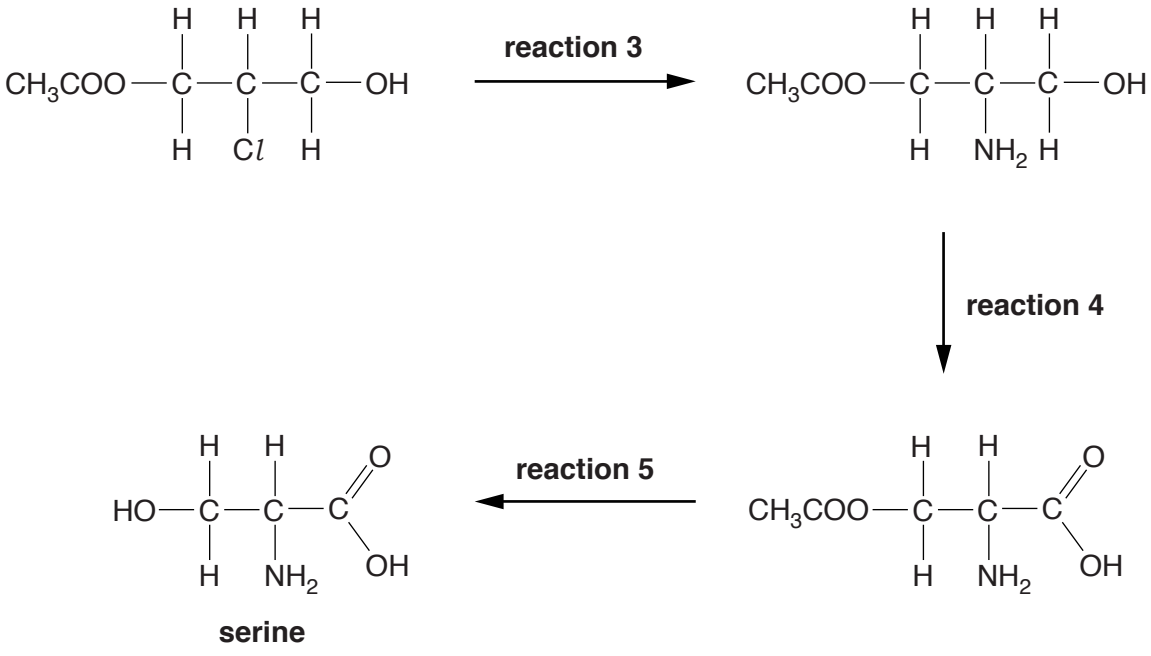
[3]

(ii) Suggest a use for the organic compound formed by **reaction 2**.

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

(iii) Serine is commonly used in organic synthesis.

One possible method of synthesising serine is shown below.



Complete the following:

Reagent and conditions used for **reaction 3**.

.....

Type of reaction for:

reaction 4 .....

reaction 5 .....

[3]

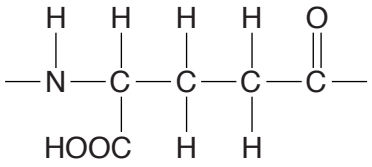
(b) Compound **E**, C_4H_7NO, is one of two optical isomers. It can be oxidised by Tollens' reagent to an α-amino acid, **F**.

The α-amino acid **F** forms two different polymers, **G** and **H**.
Polymer **G** has the empirical formula $C_4H_7NO_2$.
Polymer **H** has the empirical formula C_4H_5NO.

- Suggest structures for compound **E** and compound **F**.
- Draw repeat units of polymer **G** and polymer **H**.
- Describe how **F** forms **G** and **H**.

[6]

(c) Poly(glutamic acid) is a polymer of the amino acid, glutamic acid.



repeat unit of poly(glutamic acid)

(i) Draw the structure of glutamic acid.

[1]

(ii) A student tried to prepare poly(glutamic acid) from glutamic acid. No polymer was found in the product mixture.

The student isolated the two major compounds in the mixture. The mass spectra of these two compounds showed molecular ion (M^+) peaks at $m/z = 129$ and $m/z = 258$.

Suggest structures for these two compounds.

[2]

(d) Polymer **J** has been recently developed by scientists. The repeat unit of polymer **J** is shown below.

polymer J

(i) What are the functional groups in polymer **J**?

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

(ii) Two different monomers react to form polymer **J**.

Draw the structures of the two monomers in the boxes below.

Display the functional groups in each monomer.

[2]

(iii) Polymer **J** is used in hair spray. It can be washed away easily with hot water.

Suggest why polymer **J** is able to be washed away easily with hot water.

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

[Total: 20]

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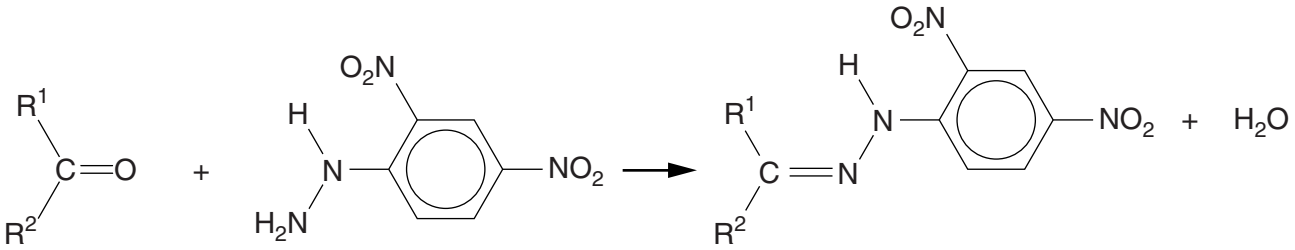
4 A student reacts compound **K** with 2,4-dinitrophenylhydrazine. An orange precipitate, **L**, was formed.



compound K **2,4-dinitrophenylhydrazine** **orange precipitate L**

The student purifies the orange precipitate, **L**, and sends the sample for analysis using ^{1}H NMR and ^{13}C NMR spectroscopy.

(a) Describe a use for NMR spectroscopy in medicine.

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

(b) **(i)** State the region of the electromagnetic spectrum used in ^{1}H NMR spectroscopy.

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

(ii) Explain why $CDCl_3$ is used as a solvent in ^{1}H NMR spectroscopy.

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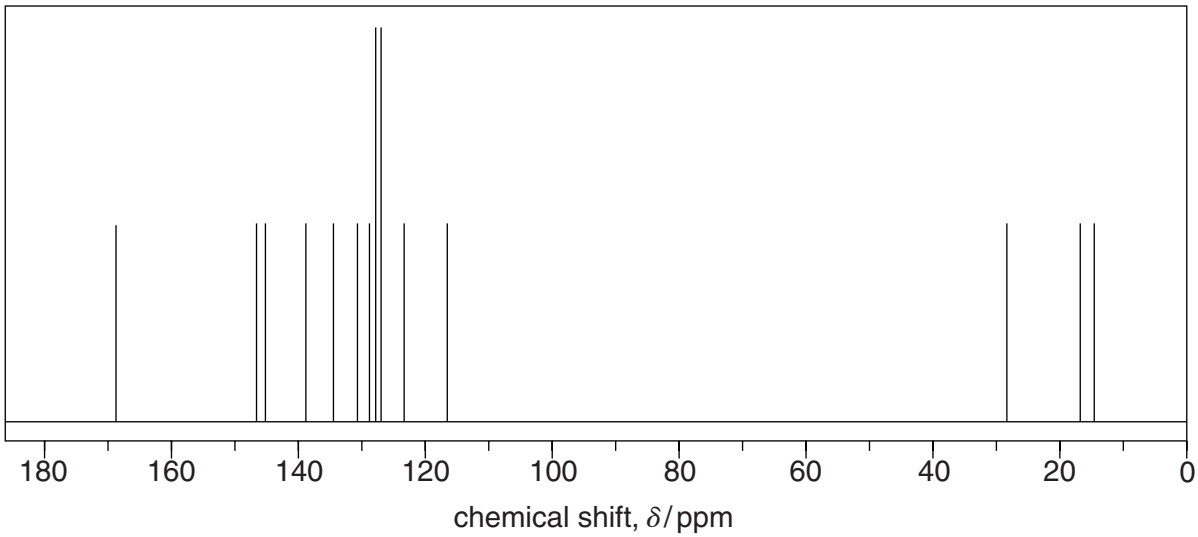
..... **[1]**

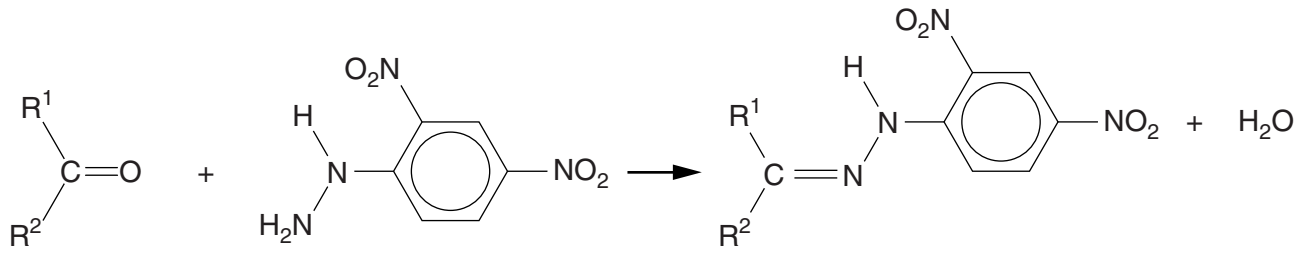
(c) The ^{13}C NMR spectrum of **L** is shown below.



How many different carbon environments (types of carbon) are present in a molecule of compound **L**?

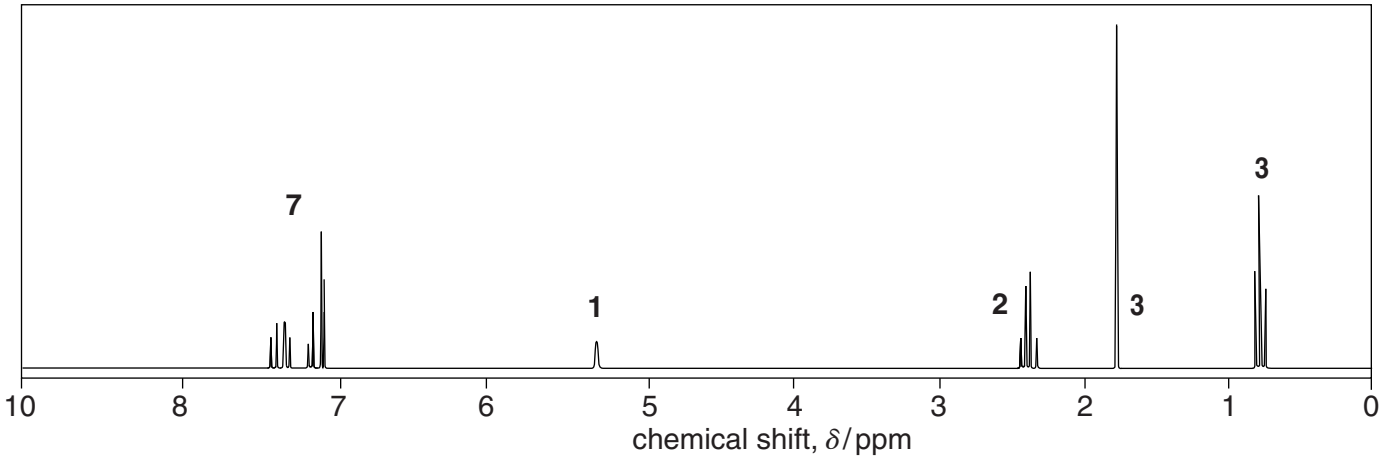
..... **[1]**

(d) The reaction of **K** to form **L** is repeated below.



compound K **2,4-dinitrophenylhydrazine** **orange precipitate L**

The ^{1}H NMR spectrum of **L** is shown below.



Use your answer to **(c)** and the data given to identify R^1, R^2 and the structure of compound **L**.

Explain how you used the chemical shifts and splitting patterns in the ^{1}H NMR spectrum and any evidence from the ^{13}C NMR spectrum.

In the ^{1}H NMR spectrum, HC–C=N– would have a peak in the range δ = 1.6–2.2 ppm.

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

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structure of compound **L**

[7]

(e) Draw the structure of compound **K**.

structure of compound **K**

[1]

[Total: 12]

END OF QUESTION PAPER

ADDITIONAL ANSWER SPACE

If additional answer space is required, you should use the following lined page(s). The question number(s) must be clearly shown in the margin.