

SECTION A

Answer **all** questions in the spaces provided.

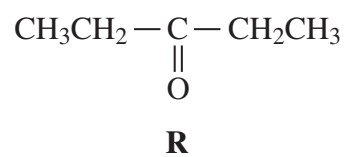
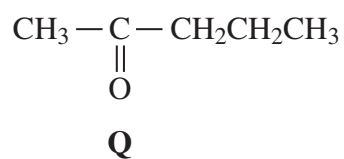
Question 1: N/A

Question 2: N/A

Question 3: N/A

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- 4 Two isomeric ketones are shown below.



- 4 (a) Name and outline a mechanism for the reaction of compound **Q** with HCN and name the product formed.

Name of mechanism

Mechanism

Name of product
(6 marks)

- 4 (b) Some students were asked to suggest methods to distinguish between isomers **Q** and **R**.

One student suggested testing the optical activity of the products formed when **Q** and **R** were reacted separately with HCN.

By considering the optical activity of these products formed from **Q** and **R**, explain why this method would **not** distinguish between **Q** and **R**.

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(3 marks)

(Extra space)

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- 4 (c) Other students suggested using mass spectrometry and the fragmentation patterns of the molecular ions of the two isomers to distinguish between them.

They predicted that only one of the isomers would have a major peak at $m/z = 57$ in its mass spectrum so that this method would distinguish between **Q** and **R**.

- 4 (c) (i) Identify the isomer that has a major peak at $m/z = 57$ in its mass spectrum.

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(1 mark)

- 4 (c) (ii) Write an equation for the fragmentation of the molecular ion of this isomer to form the species that produces the peak at $m/z = 57$.

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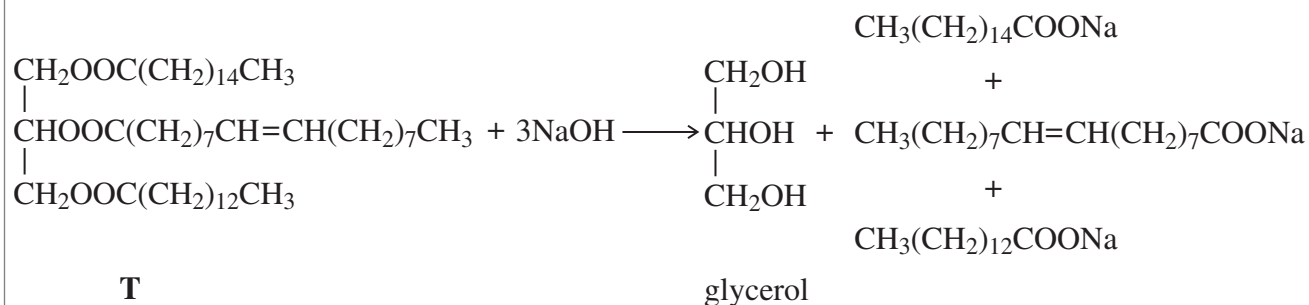
(2 marks)

- 4 (c) (iii) Predict the m/z value of a major peak in the mass spectrum of the other isomer.

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(1 mark)

- 5 The triester, **T**, shown below is found in palm oil. When **T** is heated with an excess of sodium hydroxide solution, the alcohol glycerol is formed together with a mixture of three other products as shown in the following equation.



- 5 (a) (i) Give the IUPAC name for glycerol.

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(1 mark)

- 5 (a) (ii) Give a use for the mixture of sodium salts formed in this reaction.

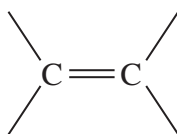
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(1 mark)

- 5 (b) When **T** is heated with an excess of methanol, glycerol is formed together with a mixture of methyl esters.

- 5 (b) (i) Give a use for this mixture of methyl esters.

.....
(1 mark)

- 5 (b) (ii) One of the methyl esters in the mixture has the IUPAC name methyl (Z)-octadec-9-enoate. Draw **two** hydrogen atoms on the diagram below to illustrate the meaning of the letter Z in the name of this ester.



(1 mark)

- 5** (b) (iii) One of the other methyl esters in the mixture has the formula $\text{CH}_3(\text{CH}_2)_{12}\text{COOCH}_3$
Write an equation for the complete combustion of one molecule of this ester.

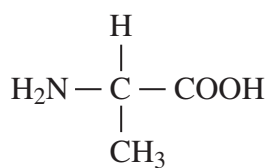
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(1 mark)

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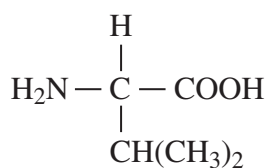
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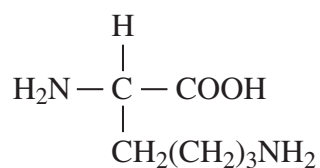
6 The three amino acids shown below were obtained by hydrolysis of a protein.



alanine



valine



lysine

6 (a) (i) Draw the zwitterion of alanine.

(1 mark)

6 (a) (ii) Draw the species formed when valine is dissolved in an alkaline solution.

(1 mark)

6 (a) (iii) Draw the species formed by lysine at low pH.

(1 mark)

- 6** (b) Draw the two dipeptides formed by the reaction of alanine with valine.

(2 marks)

- 6** (c) Name a suitable method by which the mixture of amino acids formed by hydrolysis of the protein can be separated.

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(1 mark)

Turn over for the next question

6

Turn over ►

- 7 Organic chemists use a variety of methods to identify unknown compounds. When the molecular formula of a compound is known, spectroscopic and other analytical techniques are used to distinguish between possible structural isomers. Use your knowledge of such techniques to identify the compounds described below.

Use the three tables of spectral data on the Data Sheet where appropriate.

Each part below concerns a different pair of structural isomers.

Draw **one** possible structure for each of the compounds **A** to **J**, described below.

- 7 (a) Compounds **A** and **B** have the molecular formula $\text{C}_3\text{H}_6\text{O}$
A has an absorption at 1715 cm^{-1} in its infrared spectrum and has only one peak in its ^1H n.m.r. spectrum.
B has absorptions at 3300 cm^{-1} and at 1645 cm^{-1} in its infrared spectrum and does **not** show *E-Z* isomerism.

A

B

(2 marks)

- 7 (b) Compounds **C** and **D** have the molecular formula C_5H_{12}
In their ^1H n.m.r. spectra, **C** has three peaks and **D** has only one.

C

D

(2 marks)

- 7 (c) Compounds **E** and **F** are both esters with the molecular formula $C_4H_8O_2$. In their 1H n.m.r. spectra, **E** has a quartet at $\delta = 2.3$ ppm and **F** has a quartet at $\delta = 4.1$ ppm.

E**F**

(2 marks)

- 7 (d) Compounds **G** and **H** have the molecular formula $C_6H_{12}O$. Each exists as a pair of optical isomers and each has an absorption at about 1700 cm^{-1} in its infrared spectrum. **G** forms a silver mirror with Tollens' reagent but **H** does not.

G**H**

(2 marks)

- 7 (e) Compounds **I** and **J** have the molecular formula $C_4H_{11}N$ and both are secondary amines. In their ^{13}C n.m.r. spectra, **I** has two peaks and **J** has three.

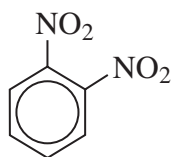
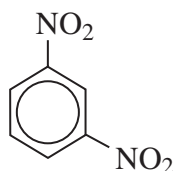
I**J**

(2 marks)

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SECTION BAnswer **all** questions in the spaces provided.

- 8** Three isomers of $C_6H_4(NO_2)_2$ are shown below.

**W****X****Y**

- 8** (a) (i) Give the number of peaks in the ^{13}C n.m.r. spectrum of each isomer.

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(3 marks)

- 8** (a) (ii) Draw the displayed formula of the compound used as a standard in recording these spectra.

(1 mark)

- 8** (b) Isomer **X** is prepared from nitrobenzene by reaction with a mixture of concentrated nitric acid and concentrated sulfuric acid.

The two acids react to form an inorganic species that reacts with nitrobenzene to form **X**.

- 8** (b) (i) Give the formula of this inorganic species formed from the two acids and write an equation to show its formation.

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(2 marks)

- 8** (b) (ii) Name and outline a mechanism for the reaction of this inorganic species with nitrobenzene to form **X**.

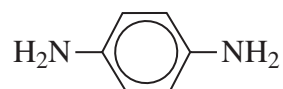
(4 marks)

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- 8 (c) Isomer **Y** is used in the production of the polymer Kevlar.

Y is first reduced to the diamine shown below.



- 8 (c) (i) Identify a suitable reagent or mixture of reagents for the reduction of **Y** to form this diamine. Write an equation for this reaction using [H] to represent the reducing agent.

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(2 marks)

- 8 (c) (ii) This diamine is then reacted with benzene-1,4-dicarboxylic acid to form Kevlar. Draw the repeating unit of Kevlar.

(2 marks)

- 8** (c) (iii) Kevlar can be used as the inner lining of bicycle tyres. The rubber used for the outer part of the tyre is made of polymerised alkenes.

State the difference in the biodegradability of Kevlar compared to that of rubber made of polymerised alkenes.

Use your knowledge of the bonding in these polymer molecules to explain this difference.

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(4 marks)

(Extra space)

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18

Turn over for the next question

Turn over ►

- 9** (a) Name and outline a mechanism for the reaction of $\text{CH}_3\text{CH}_2\text{NH}_2$ with $\text{CH}_3\text{CH}_2\text{COCl}$
- Name the amide formed.

(6 marks)

