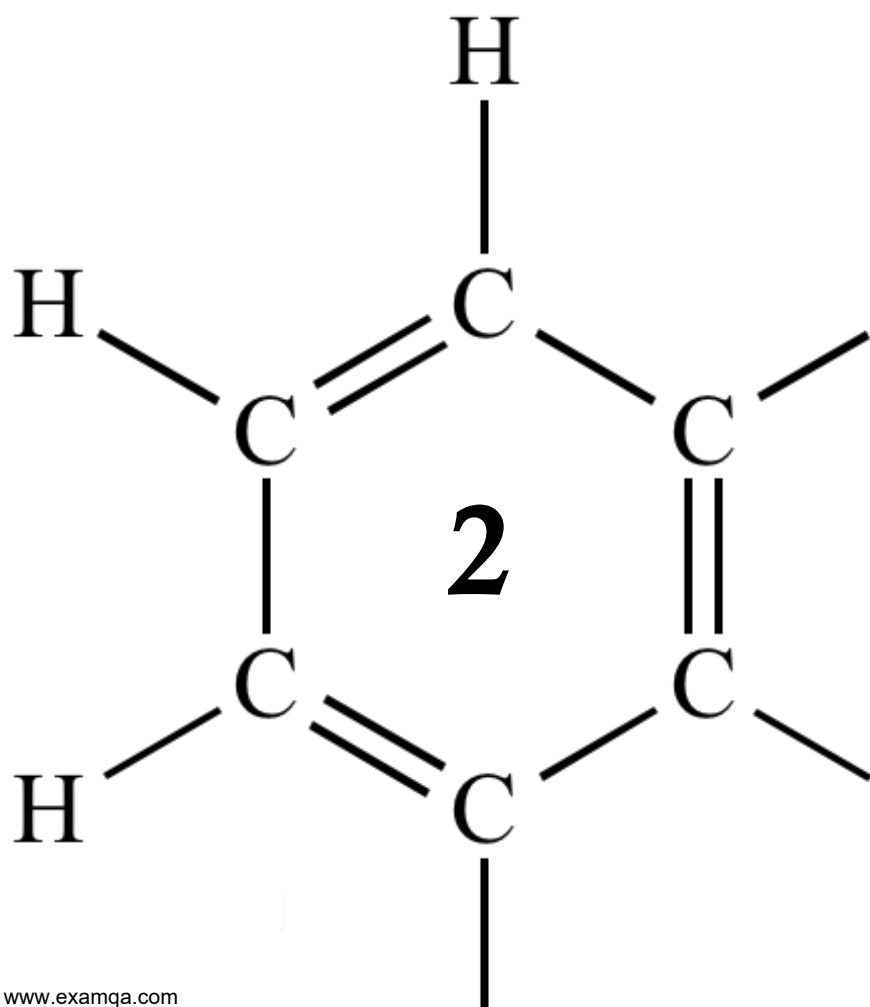


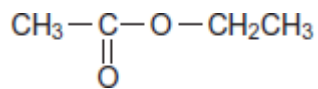
AQA A2 CHEMISTRY  
**SYNTHESIS ~ ANALYSIS**

INTRO TO ORGANIC

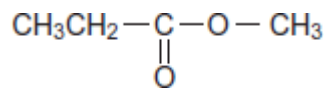


1

(a) **Ester 1** and **Ester 2** were studied by  $^1\text{H}$  n.m.r. spectroscopy.

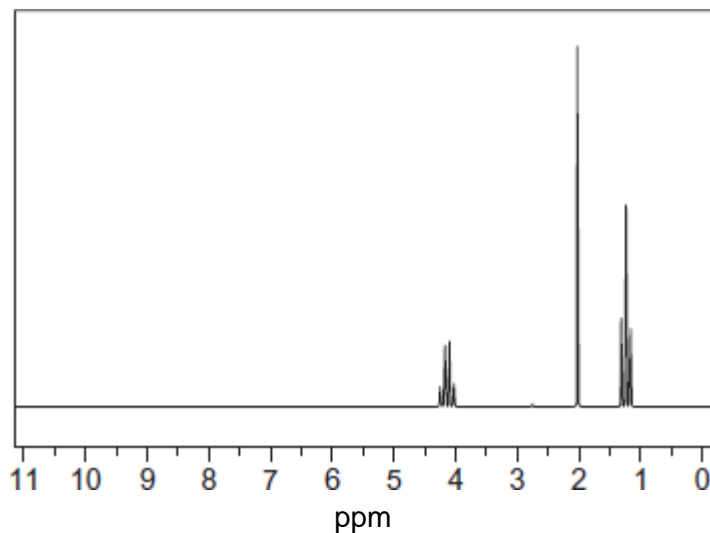


**Ester 1**



**Ester 2**

One of the two esters produced this spectrum.



Deduce which of the two esters produced the spectrum shown. In your answer, explain the position and splitting of the quartet peak at  $\delta = 4.1$  ppm in the spectrum.

Predict the  $\delta$  value of the quartet peak in the spectrum of the other ester.

Use **Table B** on the Data Sheet.

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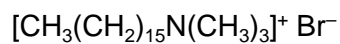
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(4)

(b) Cetrimide is used as an antiseptic.



cetrimide

Name this type of compound.

Give the reagent that must be added to  $\text{CH}_3(\text{CH}_2)_{15}\text{NH}_2$  to make cetrimide and state the reaction conditions.

Name the type of mechanism involved in this reaction.

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**(4)**

(c) Give a reagent that could be used in a test-tube reaction to distinguish between benzene and cyclohexene.

Describe what you would see when the reagent is added to each compound and the test tube is shaken.

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**(3)**

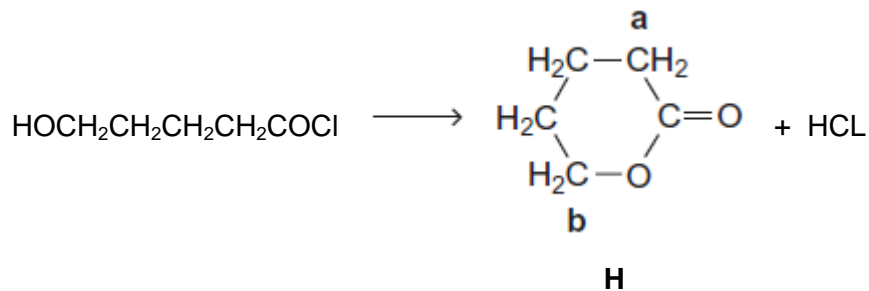
**(Total 11 marks)**

2

This question is about some isomers of  $C_5H_8O_2$

(a) Compound **H** is a cyclic ester that can be prepared as shown.

On the structure of **H**, two of the carbon atoms are labelled.



(i) Name and outline a mechanism for this reaction.

Use **Table C** on the Data Sheet to give the  $^{13}C$  n.m.r.  $\delta$  value for the carbon atom labelled **a** and the  $\delta$  value for the carbon atom labelled **b**.

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(7)

- (ii) HOCH<sub>2</sub>CH<sub>2</sub>CH<sub>2</sub>CH<sub>2</sub>COCl can also react to form a polyester in a mechanism similar to that in part (i).

Draw the repeating unit of the polyester and name the type of polymerisation involved.

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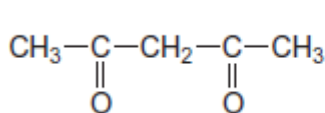
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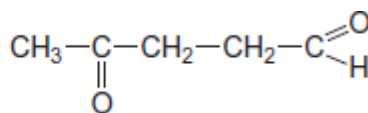
(2)

- (b) State how you could distinguish between compounds **J** and **K** by a simple test-tube reaction.

State how you could distinguish between **J** and **K** by giving the number of peaks in the <sup>1</sup>H n.m.r. spectrum of each compound.



**J**



**K**

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(5)

- (c) Draw the structure of each of the following isomers of  $C_5H_8O_2$   
Label each structure you draw with the correct letter **L**, **M**, **N**, **P** or **Q**.

**L** is methyl 2-methylpropenoate.

**M** is an ester that shows E-Z stereoisomerism.

**N** is a carboxylic acid with a branched carbon chain and does **not** show stereoisomerism.

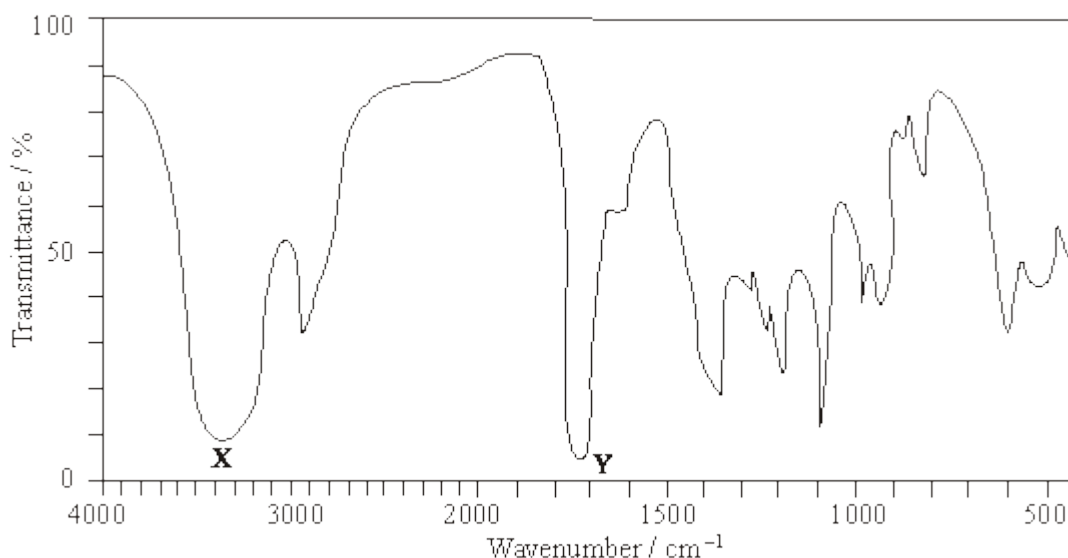
**P** is an optically active carboxylic acid.

**Q** is a cyclic compound that contains a ketone group and has only two peaks in its  $^1H$  n.m.r. spectrum.

(5)  
(Total 19 marks)

3

- (a) The infra-red spectrum of compound **A**,  $C_3H_6O_2$ , is shown below.



Identify the functional groups which cause the absorptions labelled **X** and **Y**.

Using this information draw the structures of the three possible structural isomers for **A**.

Label as **A** the structure which represents a pair of optical isomers.

(6)

(b) Draw the structures of the three **branched-chain** alkenes with molecular formula  $C_5H_{10}$

Draw the structures of the three dibromoalkanes,  $C_5H_{10}Br_2$ , formed when these three alkenes react with bromine.

One of these dibromoalkanes has only three peaks in its proton n.m.r. spectrum. Deduce the integration ratio and the splitting patterns of these three peaks.

(10)  
(Total 16 marks)

4

Which one of the following can exhibit both geometrical and optical isomerism?

- A**  $(CH_3)_2C=CHCH(CH_3)CH_2CH_3$   
**B**  $CH_3CH_2CH=CHCH(CH_3)CH_2CH_3$   
**C**  $(CH_3)_2C=C(CH_2CH_3)_2$   
**D**  $CH_3CH_2CH(CH_3)CH(CH_3)C=CH_2$

(Total 1 mark)

5

Each of the parts (a) to (e) below concerns a different pair of isomers.

Draw one possible structure for each of the species **A** to **J**, using Table 2 on the Data Sheet where appropriate.

- (a) Compounds **A** and **B** have the molecular formula  $C_5H_{10}$   
**A** decolourises bromine water but **B** does not.

**A**    **B**

(2)

(b) Compounds **C** and **D** have the molecular formula  $C_2H_4O_2$

Each has an absorption in its infra-red spectrum at about  $1700\text{ cm}^{-1}$  but only **D** has a broad absorption at  $3350\text{ cm}^{-1}$

**C**   **D**

(2)

(c) Compounds **E** and **F** are esters with the molecular formula  $C_5H_{10}O_2$

The proton n.m.r. spectrum of **E** consists of two singlets only whereas that of **F** consists of two quartets and two triplets.

**E**   **F**

(2)

(d) Compounds **G** and **H** have the molecular formula  $C_3H_6Cl_2$  **G** shows optical activity but **H** does not.

**G**   **H**

(2)



- (e) Compounds **I** and **J** have the molecular formula  $C_6H_{12}$

Each has an absorption in its infra-red spectrum at about  $1650\text{ cm}^{-1}$  and neither shows geometrical isomerism. The proton n.m.r. spectrum of **I** consists of a singlet only whereas that of **J** consists of a singlet, a triplet and a quartet.

**I**      **J**

(2)  
(Total 10 marks)

6

- (a) Addition reactions to both alkenes and carbonyl compounds can result in the formation of isomeric compounds.

- (i) Choose an alkene with molecular formula  $C_4H_8$  which reacts with HBr to form two structural isomers. Give the structures of these two isomers and name the type of structural isomerism shown.

Outline a mechanism for the formation of the major product.

- (ii) Using HCN and a suitable carbonyl compound with molecular formula  $C_3H_6O$ , outline a mechanism for an addition reaction in which two isomers are produced. Give the structures of the two isomers formed and state the type of isomerism shown.

(14)

- (b) Explain why ethanoyl chloride reacts readily with nucleophiles.  
Write an equation for one nucleophilic addition–elimination reaction of ethanoyl chloride.  
(A mechanism is not required.)

(4)  
(Total 18 marks)