

13C-NMC

Question Paper

Level	Pre U
Subject	Chemistry
Exam Board	Cambridge International Examinations
Topic	13C-NMC
Booklet	Question Paper

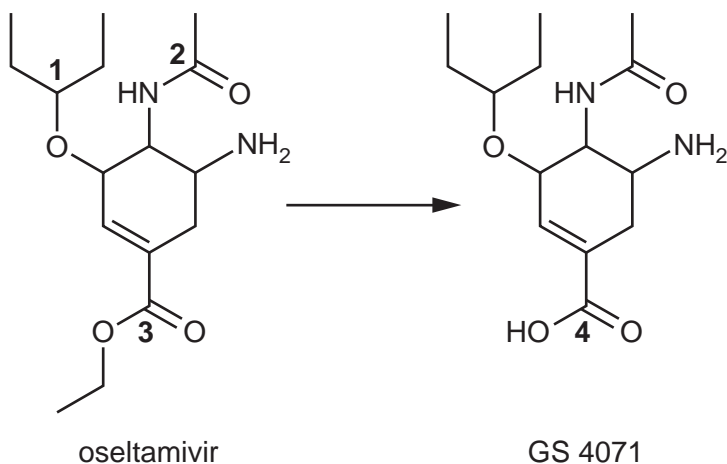
Time Allowed: 54 minutes

Score: /45

Percentage: /100

Grade Boundaries:

1. Oseltamivir is an anti-viral drug that is converted to its active form, GS 4071, in the body after being administered.



- (a) State the names of the functional group levels of the carbon atoms numbered **1** and **2** in the structure of oseltamivir.

carbon **1**

carbon **2** [2]

- (b) With reference to the functional group levels of the carbon atoms numbered **3** and **4**, what type of reaction is involved in the conversion of oseltamivir into GS 4071? Explain your answer.

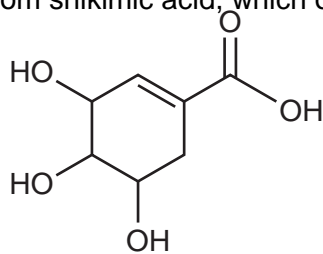
.....

 [2]

- (c) Use skeletal formulae to give the structures of all three products formed from the hydrolysis of the ester and amide links in oseltamivir by hot aqueous hydrochloric acid.

[4]

Oseltamivir can be produced from shikimic acid, which occurs naturally in star anise.

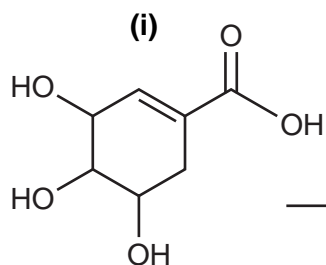


shikimic acid

- (d) Give the molecular formula of shikimic acid.

..... [1]

- (e) Give the structure of the organic product when shikimic acid reacts with each of the following reagents.

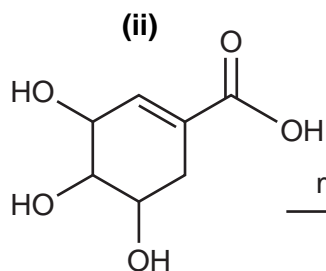


shikimic acid

bromine, $\text{Br}_2(\text{l})$



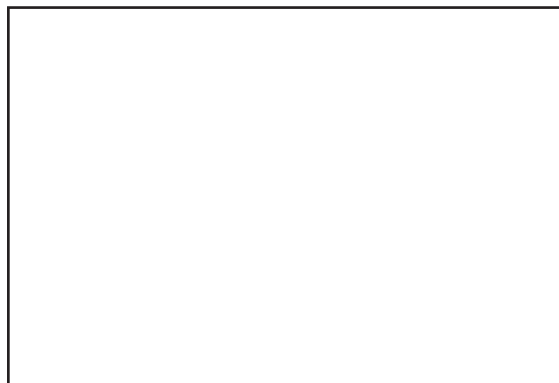
[1]



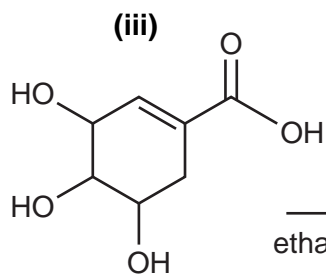
shikimic acid

methanol, CH_3OH

conc. H_2SO_4



[1]



shikimic acid

excess

ethanoyl chloride CH_3COCl



[2]

- (f) Using the numbers on the diagram of shikimic acid's structure in Fig. 5.1 indicate (by putting numbers in the boxes) which carbon atoms in the molecule are responsible for each signal in its ^{13}C NMR spectrum in Fig. 5.2. The precise order of carbons within the group of two and the group of three are not required.

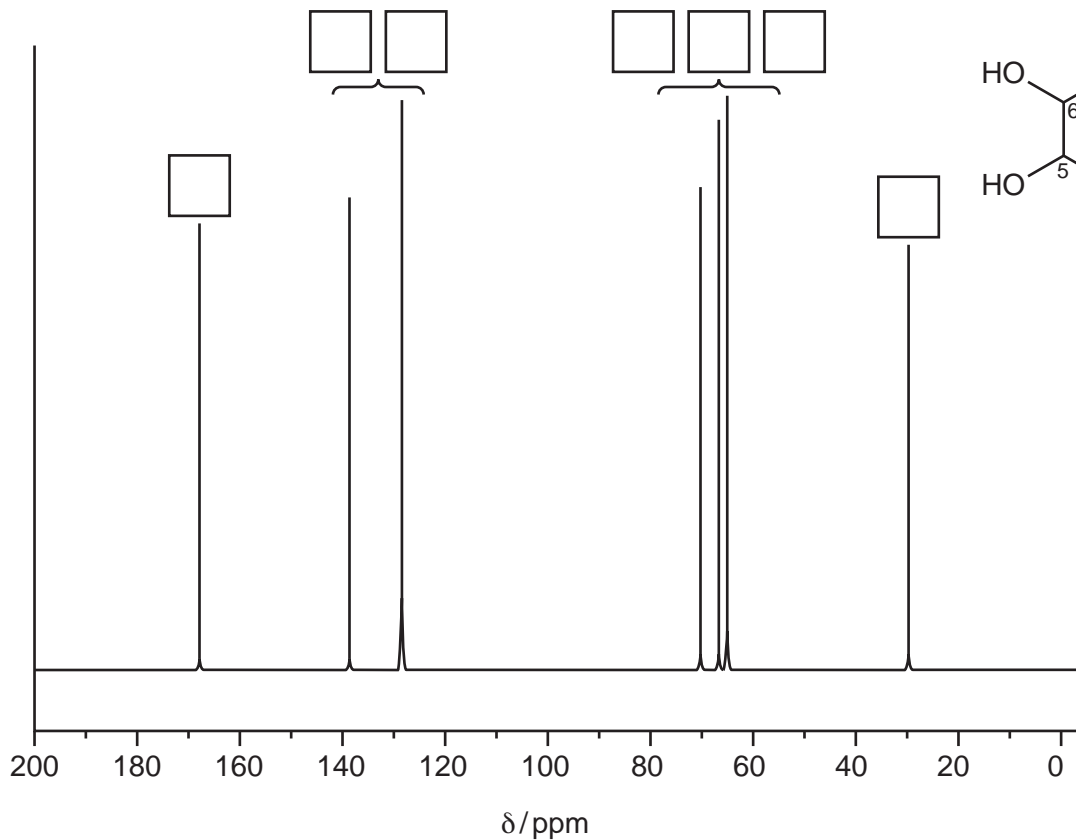


Fig. 5.1

Fig. 5.2

[3]

(g) Under suitable conditions shikimic acid reacts with HBr in a 1:1 ratio to produce a mixture of two products each with the molecular formula $C_7H_{11}BrO_5$.

(i) Give the full name of the mechanism of this reaction.

..... [1]

(ii) Draw the structures of the two possible products.

[2]

(iii) Suggest why one of the two products will be present in greater quantities.

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

[Total: 21]

2. Cyanoacrylate is the generic name for cyanoacrylate based fast-acting glues such as ethyl 2-cyanoacrylate. The skeletal formula of ethyl 2-cyanoacrylate is given in Fig. 5.1.

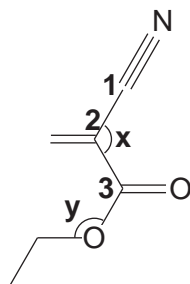


Fig. 5.1

- (a) Give the molecular formula of ethyl 2-cyanoacrylate.

.....[1]

- (b) Give the bond angles labelled **x** and **y**.

bond angle **x**

bond angle **y** [2]

- (c) Write the **names** of the functional group levels of the carbon atoms numbered **1**, **2**, and **3**.

1

2

3 [2]

(d) Ethyl 2-cyanoacrylate rapidly undergoes addition polymerisation in the presence of a suitable nucleophile to form long, strong chains which join the bonded surfaces together. The presence of moisture can therefore cause the glue to set, so exposure to moisture in the air can cause a tube or bottle of glue to become unusable over time.

(i) Explain what is meant by the term *nucleophile*.

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

(ii) Draw the structure of part of the polymer chain that would be formed, showing **three** repeat units.

[2]

- (e) The reduction of ethyl 2-cyanoacrylate with LiAlH_4 in ether produces two compounds, **Q** and **R**. **Q** reacts with ethanoyl chloride in a 1:2 molar ratio to form **S**. **R** reacts with ethanoyl chloride in a 1:1 ratio to form **T**. The ^1H NMR spectrum of **T** is shown in Fig. 5.2 and the ^{13}C NMR spectrum of **T** is shown in Fig. 5.3.

If ethyl 2-cyanoacrylate is instead reduced with hydrogen using a nickel catalyst then there is only a single product, **U**. The ^1H NMR spectrum of **U** has six signals, one of which disappears on shaking with D_2O .

Draw the structural formula of each of the compounds **Q**, **R**, **S**, **T** and **U**. Explain the reactions and the forms of the spectra in Fig. 5.2 and Fig. 5.3. This should include the identification of the atoms or groups of atoms responsible for each signal.

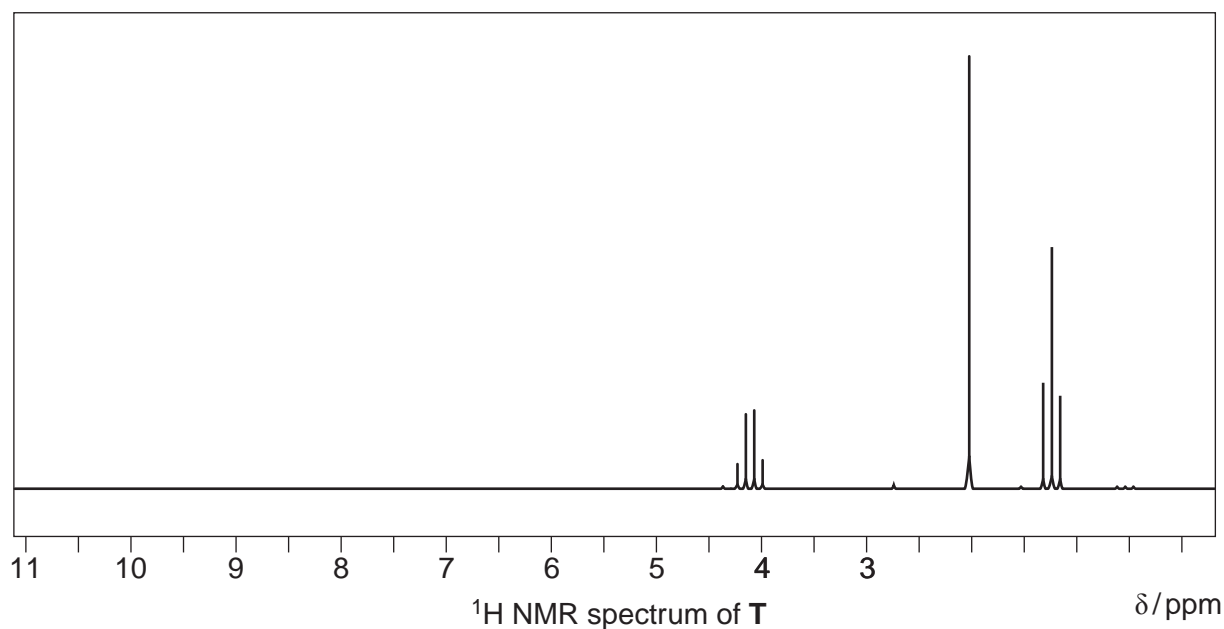


Fig. 5.2

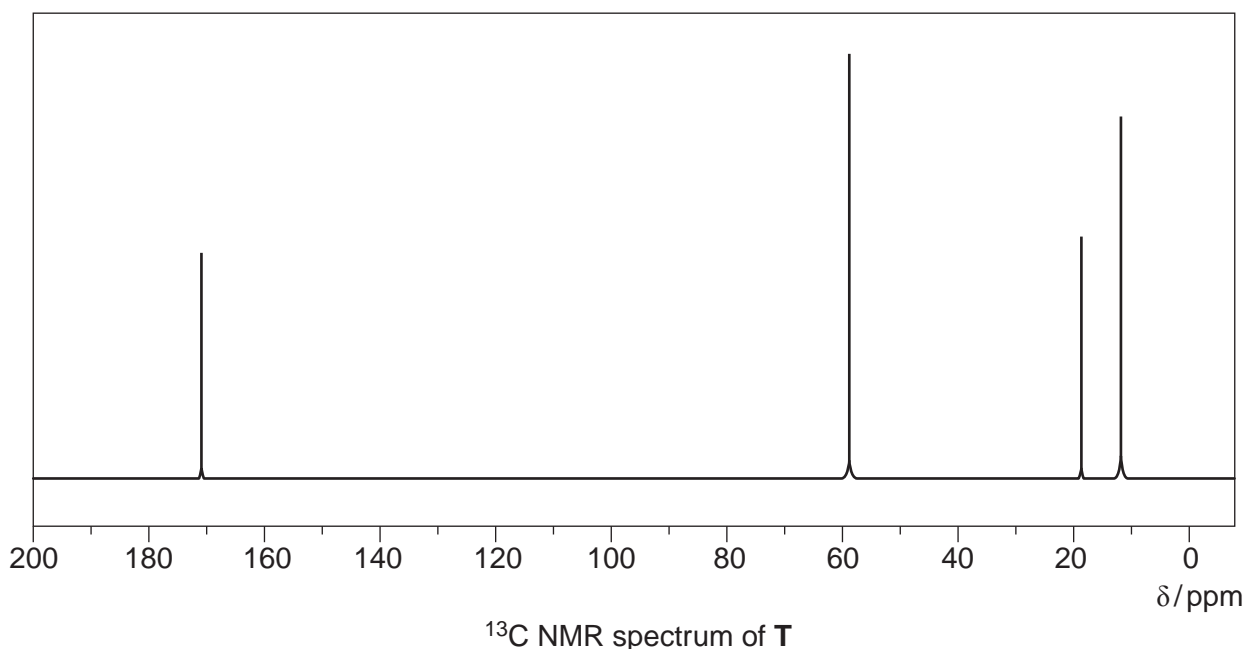


Fig. 5.3

Structural formulae

Q

R

S

T

U

[5]

Explanations

Reactions of **Q** and **R** with ethanoyl chloride

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

^1H NMR of **T**

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

^{13}C NMR of **T**

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

^1H NMR of **U**

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

[Total: 26]