



A-Level Chemistry

Carbon NMR

Question Paper

Time available: 40 minutes

Marks available: 35 marks

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1.

This question is about isomers with the molecular formula $C_5H_{10}O$

- (a) Draw the skeletal formula of a branched chain aldehyde with molecular formula $C_5H_{10}O$ that is optically active.

(1)

- (b) Describe how you distinguish between separate samples of the two enantiomers of the branched chain aldehyde $C_5H_{10}O$

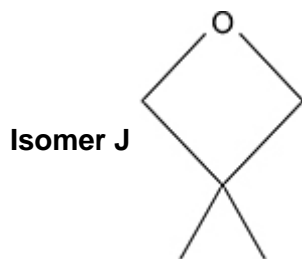
(2)

- (c) Draw the *E* and *Z* forms of a structural isomer of $C_5H_{10}O$ that shows **both** optical and geometric isomerism.

<i>E</i> isomer	<i>Z</i> isomer

(2)

- (d) Isomer J is cyclic and has an ether functional group (C–O–C)
Isomer J has only three peaks in its ^{13}C NMR spectrum.



Draw **two** other cyclic isomers of $\text{C}_5\text{H}_{10}\text{O}$ that have an ether functional group and only three peaks in their ^{13}C NMR spectra.

(2)

(Total 7 marks)

2.

This question is about citric acid, a hydrated tricarboxylic acid. Its formula can be represented as $\text{H}_3\text{Y}\cdot x\text{H}_2\text{O}$

- (a) A 1.50 g sample of $\text{H}_3\text{Y}\cdot x\text{H}_2\text{O}$ contains 0.913 g of oxygen by mass.
The sample burns completely in air to form 1.89 g of CO_2 and 0.643 g of H_2O

Show that the empirical formula of citric acid is $\text{C}_3\text{H}_5\text{O}_4$

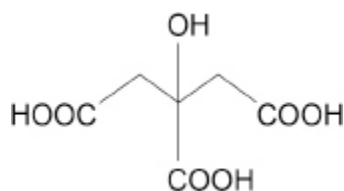
(5)

- (b) A 3.00 g sample of $H_3Y \cdot xH_2O$ ($M_r = 210.0$) is heated to constant mass. The anhydrous H_3Y that remains has a mass of 2.74 g

Show, using these data, that the value of $x = 1$

(2)

The figure shows the structure of H_3Y



- (c) Complete this IUPAC name for H_3Y

_____ propane-1, 2, 3-tricarboxylic acid

(1)

- (d) State the number of peaks you would expect in the ^{13}C NMR spectrum for H_3Y

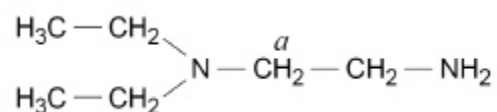
(1)

(Total 9 marks)

3.

There are several isomers with the molecular formula $C_6H_{16}N_2$

(a) One isomer is shown.



Give the number of peaks in the ^{13}C NMR spectrum of this isomer.

State and explain the splitting pattern of the peak for the hydrogens labelled *a* in its 1H NMR spectrum.

Number of ^{13}C peaks _____

Splitting pattern _____

Explanation _____

(3)

(b) Draw the structure of the isomer of $C_6H_{16}N_2$ used to make nylon 6,6

(1)

- (c) Draw the structure of the isomer of $C_6H_{16}N_2$ that contains two **primary** amine groups and has only two peaks in its ^{13}C NMR spectrum.

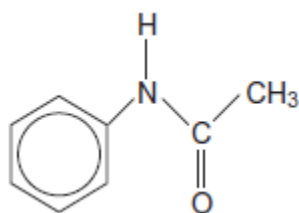
(1)

- (d) Draw the structure of the isomer of $C_6H_{16}N_2$ that contains two **tertiary** amine groups and has only two peaks in its ^{13}C NMR spectrum.

(1)

(Total 6 marks)

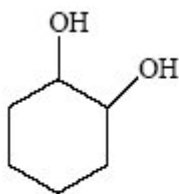
4. The structure of N-phenylethanamide is



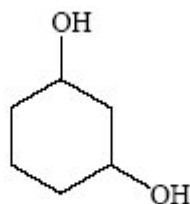
Use this structure to determine the number of peaks in the ^{13}C n.m.r. spectrum of N-phenylethanamide.

(Total 1 mark)

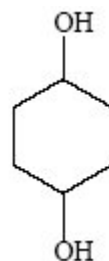
5. Three cyclic alcohols, cyclohexan-1,2-diol, cyclohexan-1,3-diol and cyclohexan-1,4-diol were compared using ^{13}C n.m.r. spectroscopy.



cyclohexan-1,2-diol

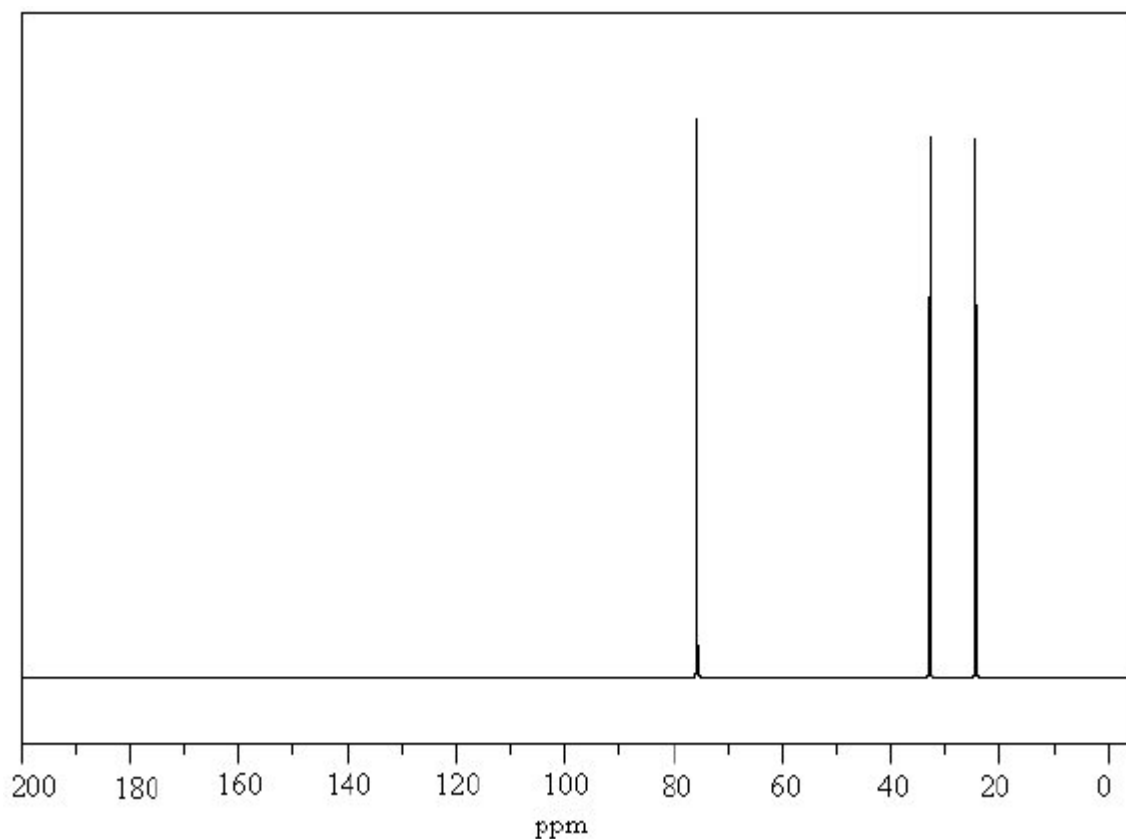


cyclohexan-1,3-diol



cyclohexan-1,4-diol

The ^{13}C n.m.r. spectrum of cyclohexan-1,2-diol is shown below.



(a) (i) Explain why there are three peaks.

(ii) Proton n.m.r. chemical shift data is shown in Table 1 on the reverse of the Periodic Table. Chemical shift values for ^{13}C vary similarly with chemical environment.

Suggest the δ value of the peak in the spectrum above which corresponds to the absorption for carbon atom 1 in cyclohexan-1,2-diol.

(b) (i) Predict the number of peaks in the ^{13}C n.m.r. spectrum of cyclohexan-1,3-diol.

(ii) Predict the number of peaks in the ^{13}C n.m.r. spectrum of cyclohexan-1,4-diol.

(c) Suggest why the structures drawn above represents several stereoisomers.

(Total 5 marks)

6.

Isomers **X** and **Y** have the molecular formula C_5H_8O

Isomer **X**



Isomer **Y**



(a) Give the IUPAC name for isomer **X**.

(1)

(b) Explain how and why isomers **X** and **Y** can be distinguished by comparing **each** of their

- boiling points
- ^{13}C NMR spectra
- infrared spectra.

Use data from Tables **A** and **C** in the Data Booklet in your answer.

(6)

(Total 7 marks)