

Other 1/2 spin Nuclei

Question Paper 1

Level	Pre U
Subject	Chemistry
Exam Board	Cambridge International Examinations
Topic	Other 1/2 spin nuclei-NMC
Booklet	Question Paper 1

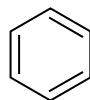
Time Allowed: 52 minutes

Score: /43

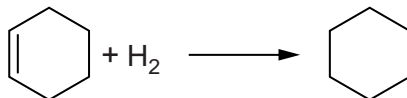
Percentage: /100

Grade Boundaries:

1. Kekulé proposed the following structure for benzene.



- (a) The enthalpy of hydrogenation of cyclohexene, as shown, is -121 kJ mol^{-1} .



Based on this value for cyclohexene it is possible to calculate that the enthalpy of hydrogenation of benzene, based on Kekulé's structure, should be -363 kJ mol^{-1} .

Explain the difference between this calculated value and the actual value for the enthalpy of hydrogenation of benzene of -209 kJ mol^{-1} .

.....

 [2]

- (b) Benzene undergoes electrophilic substitution reactions.

- (i) What is meant by the term *electrophile*?

.....
 [1]

- (ii) Nitrobenzene, $\text{C}_6\text{H}_5\text{NO}_2$, can be formed from benzene. Give the reagents and conditions necessary for this process and identify the electrophile.

reagents

conditions

electrophile [3]

(c) Fig. 5.1 shows a reaction sequence starting from nitrobenzene.

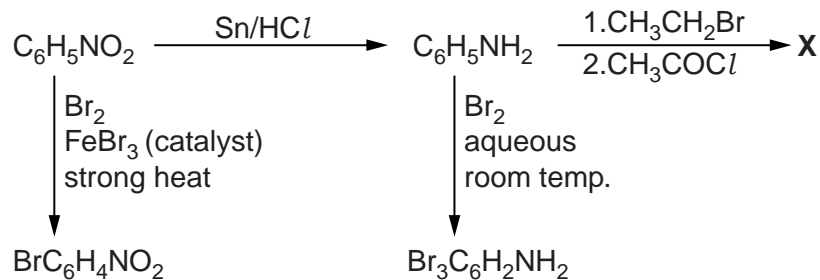


Fig. 5.1

(i) Explain why the bromination of phenylamine, $\text{C}_6\text{H}_5\text{NH}_2$, is possible with the mild conditions shown in Fig. 5.1.

.....

 [3]

(ii) Give the equation for the reaction between nitrobenzene and the reducing mixture, Sn/HCl . You should use $[\text{H}]$ to represent the reducing agent in your equation.

..... [1]

(d) (i) Compound **X**, in Fig. 5.1, has the composition by mass:

carbon, 73.59%; hydrogen, 8.03%; nitrogen, 8.58%; oxygen, 9.80%.

It has a relative molecular mass of 163.

Calculate the molecular formula of **X**.

- (ii) The ^1H NMR of **X** has a complex signal between 7.00 ppm and 7.55 ppm because of the five protons on its benzene ring, and three other signals as partly detailed in Table 5.1.

Table 5.1

δ/ppm	integration ratio	splitting pattern
1.12	3	
1.83		singlet
3.75	2	

Complete Table 5.1, give the structure of **X**, and explain the origin of the ^1H NMR signals.

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..... [4]

[Total: 17]

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.

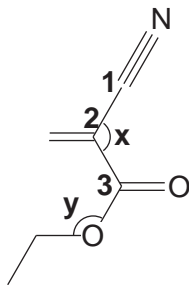


Fig. 5.1

- (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.

- (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.

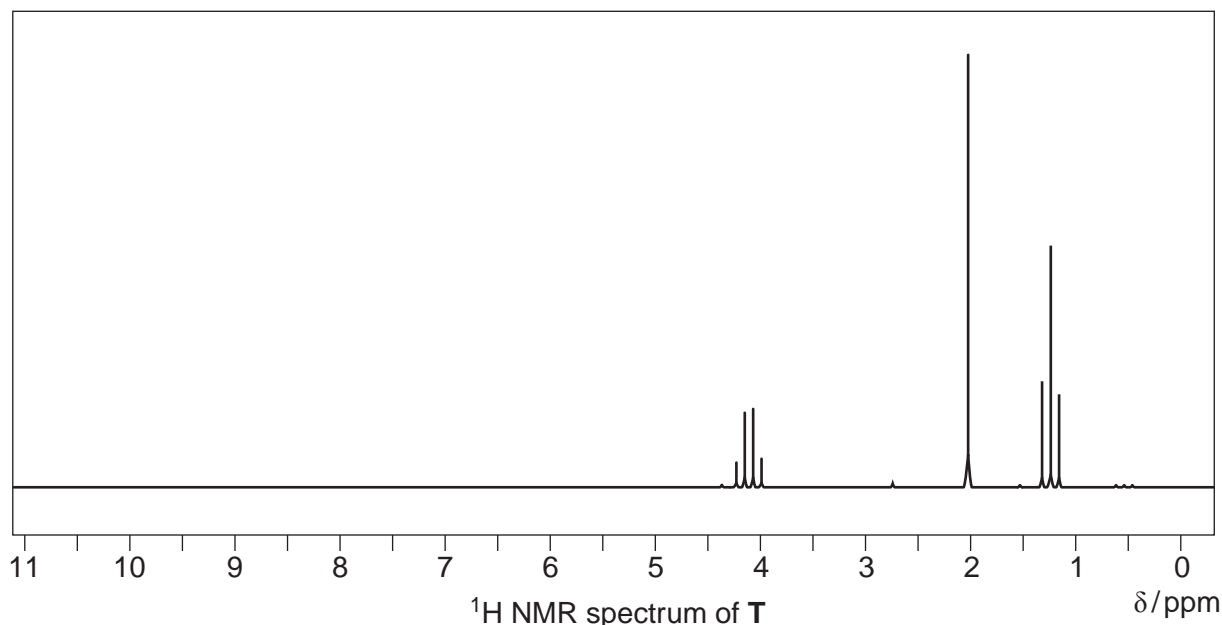


Fig. 5.2

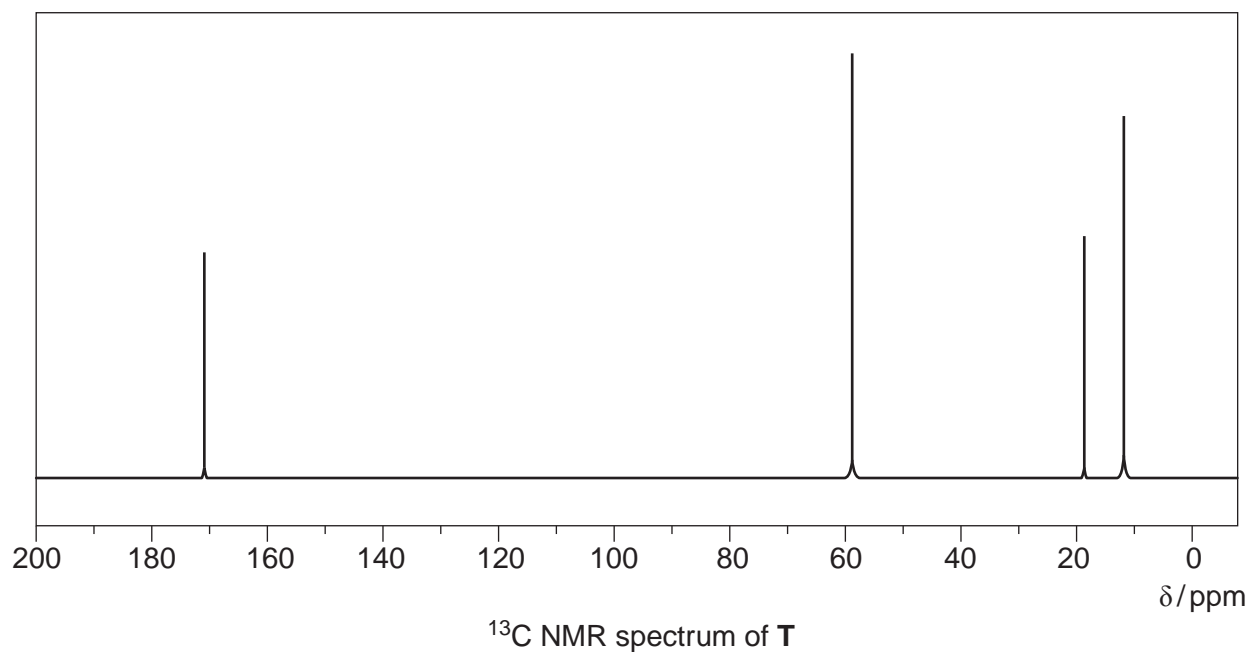


Fig. 5.3

Structural formulae

Q

R

S

T

U

[5]

Explanations

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

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.....[3]

^1H NMR of **T**

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.....[3]

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

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

^1H NMR of **U**

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

[Total: 26]