13C-NMC

Question Paper

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

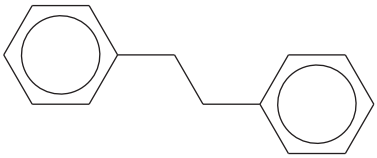
Time Allowed: **28 minutes**

Score: **/23**

Percentage: **/100**

Grade Boundaries:

1. A survey in 2008 of the 24 million known organic compounds identified the most common structural motifs. The 3rd most popular shape (after the hexagon and pentagon) was based on the 1,2-diphenylethane molecule.



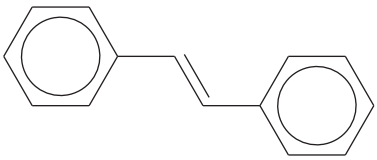
(a) How many signals would there be in the carbon-13 NMR spectrum of the 1,2-diphenylethane molecule?

.....[1]

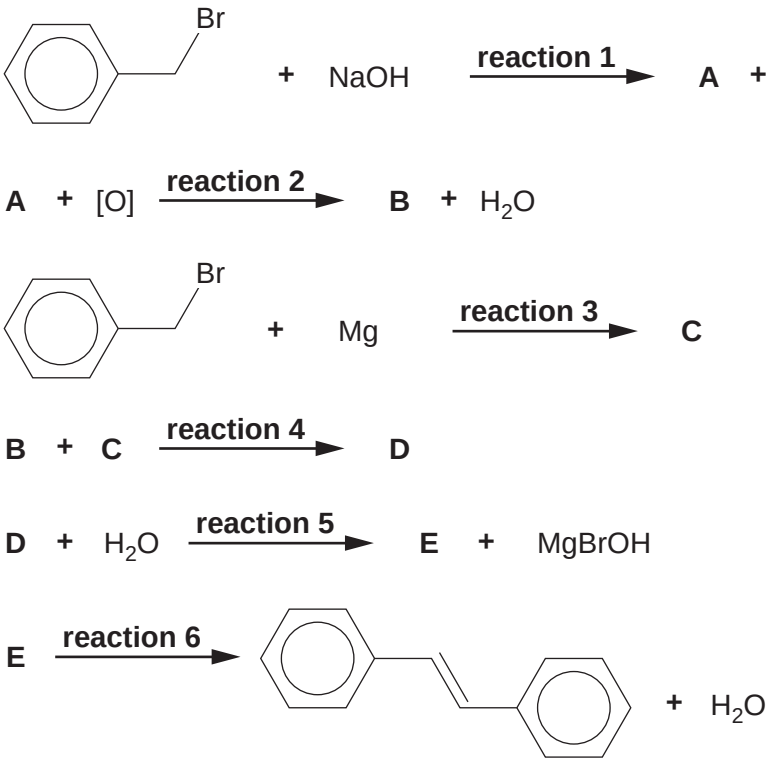
(b) If one of the hydrogen atoms on one of the phenyl groups of 1,2-diphenylethane is substituted with a chlorine atom, how many possible isomers would there be?

.....[1]

A closely related compound to 1,2-diphenylethane is 1,2-diphenylethene, commonly known as stilbene.



Stilbene can be synthesised from (bromomethyl)benzene according to the scheme below. The reactions are labelled **1** to **6** above the reaction arrows. The benzene ring does not take part in any of these reactions.



(c) **Reaction 2** is a partial oxidation. In the equation [O] represents the oxygen atom provided from some suitable reagents. Suggest such a reagent.

.....[1]

(d) What is the name of the **type** of compound produced in **reaction 3**?

.....[1]

(e) Classify the **type** of reaction in **1**, **5** and **6**.

reaction 1 .....[1]

reaction 5 .....[1]

reaction 6 .....[1]

(f) Draw the structures of unknowns **A** to **E**.

A

[1]

B

[1]

C

[1]

D

[1]

E

[1]

[Total: 12]

2. **(a)** Chemists from the University of Cambridge have used Au_{55} nanoparticles to catalyse a reaction of oxygen with phenylethene (styrene), $C_6H_5{-}CH{=}CH_2$, (*Nature*, 2008). Three products, **A**, **B** and **C**, were observed. Use the following observations to complete the structure of **A**, **B** and **C**.

- The phenyl ($C_6H_5{-}$) group remains unchanged in **A**, **B** and **C**.
- **A** has the molecular formula C_7H_6O;

  B and **C** both have the molecular formula C_8H_8O.
- When warmed with Tollens' reagent (ammoniacal silver nitrate) compound **A** produces a silver mirror but compounds **B** and **C** do not.
- The infra-red spectra of compounds **A** and **B** each have an intense peak at around 1700 cm^{-1} but that of compound **C** does not.
- None of the compounds' infra-red spectra show any broad signals above 3000 cm^{-1}.
- Compound **C** is the most reactive and unstable of the three. It contains a ring of three atoms.

structure of **A**

$C_6H_5{-}$

structure of **B**

$C_6H_5{-}$

Structure of **C**

$C_6H_5{-}$

[3]

(b) **(i)** Draw a dot-cross diagram for the hydroxonium ion, H_3O^+, showing only outer-shell electrons.

[2]

(ii) Alkyl oxonium ions are analogues of H_3O^+ where the oxygen atom is bonded to alkyl groups rather than to hydrogen atoms. The tripropyl oxonium ion is a typical alkyl oxonium ion.

- Write down the molecular formula of the tripropyl oxonium ion.

  .....

- Deduce the m/z of the molecular ion peak in its mass spectrum.

  .....

- Deduce the number of signals in its ^{13}C NMR spectrum.

  ..... [3]

(iii) Oxatriquinane is an alkyl oxonium ion whose synthesis was reported recently (*Journal of the American Chemical Society*, 2008). It was found to be surprisingly stable in water, and has:

- a molecular formula of $C_9H_{15}O^+$
- only two signals in its ^{13}C NMR spectrum
- no carbon-carbon multiple bonds
- multiple rings in its structure.

Suggest a structure for oxatriquinane.

[1]

(c) Chemists have recently synthesised the smallest "beakers" for carrying out chemical reactions (*Nature Chemistry*, 2009). The "beakers" are the junctions from a network of hollow polymer nanofibres. The volume of the beakers is about $4 \times 10^{-18}\,dm^3$.

(i) A "beaker" is full of a solution of glucose of concentration $5 \times 10^{-4}\,mol\,dm^{-3}$. Calculate the amount (in moles) of glucose in the "beaker".

..... mol [1]

(ii) Use your answer to part **(i)** to calculate the number of glucose molecules in the "beaker".

.....[1]

[Total: 11]