

29. An introduction to A Level organic chemistry

29.3 Shapes of aromatic organic molecules; σ and π bonds

Paper 4

Question Paper

- 1 (b) The compound C_6H_6 has many structural isomers. Four suggested structures of C_6H_6 are shown in Fig. 6.1.

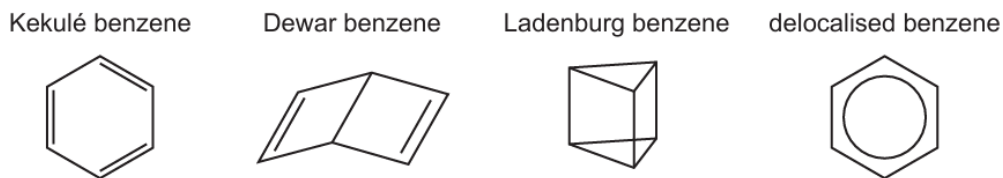


Fig. 6.1

Using Fig. 6.1, complete Table 6.1 to predict the number of carbon atoms that have sp , sp^2 and sp^3 hybridisation in Kekulé benzene, Dewar benzene and Ladenburg benzene.

Table 6.1

C_6H_6 structure	sp hybridised	sp^2 hybridised	sp^3 hybridised
Kekulé benzene			
Dewar benzene			
Ladenburg benzene			

[2]

- (c) Describe the shape of delocalised benzene.

Include the geometry of each carbon, the C-C-H bond angle and the type of bond(s) between the carbon atoms and between the carbon and hydrogen atoms.

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..... [2]

- (d) Suggest why Dewar benzene and Ladenburg benzene are unstable isomers of C_6H_6 .

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..... [1]

- 2** Benzene reacts with chlorine gas to form chlorobenzene. This reaction can be described as the reaction between benzene molecules and Cl^+ ions. The Cl^+ ions are formed by adding a suitable catalyst to the chlorine gas.

(c) There are six carbon atoms in diagram 2.

State how many of these carbon atoms are sp hybridised, sp^2 hybridised, and sp^3 hybridised.

sp hybridised

sp^2 hybridised

sp^3 hybridised

[1]

- 3 (a)** State the hybridisation of the carbon atoms and the C–C–H bond angle in benzene, C_6H_6 . Explain how orbital overlap leads to the formation of σ and π bonds in benzene.

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..... [3]

- 4 (d) The ligand bipyridine consists of two pyridine rings.

Pyridine, C_5H_5N , and benzene, C_6H_6 , have similar planar, cyclic structures.

pyridine



Fig. 4.2

By reference to the hybridisation of the carbon atoms and the nitrogen atom, and orbital overlap, suggest how the σ and π bonds are formed in a pyridine molecule.

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..... [3]

- 5 Benzene, C_6H_6 , is an aromatic molecule.

- (a) State the C–C–C bond angle and the hybridisation shown by the carbon atoms in benzene.

bond angle

hybridisation

[1]

- 6 (a) (i) When benzene undergoes nitration a nitro group substitutes at a carbon atom.

State the shape (geometry) around the substituted carbon atom

- in the benzene molecule,
- in the intermediate complex,
- in the nitrobenzene product.

[2]

- 7 (a)** Describe the structure of a benzene molecule, C_6H_6 .

Your answer should include:

- the shape of the molecule
- the relative lengths of the C–C bonds
- bond angles
- the hybridisation of the carbon atoms
- the overlap between orbitals that produces each type of bond present.

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..... [4]

- 8 (a)** By reference to the formation of σ and π bonds, describe and explain the shape of a benzene molecule, C_6H_6 .

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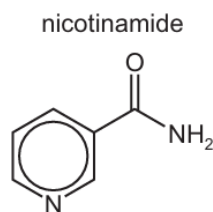
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..... [3]

- 9 The structure of nicotinamide is shown.



- (a) The nitrogen atom in the six-membered ring has one electron in an unhybridised p-orbital. This electron becomes delocalised, becoming part of a single delocalised system of electrons. This delocalised system also includes:

- electrons from the carbon atoms in the six-membered ring
- the two electrons in the π bond of the C=O group
- the two electrons in the lone pair on the nitrogen atom of the amide group.

- (i) State the number of delocalised electrons in one nicotinamide molecule.

..... [1]

- (ii) Predict the H–N–H bond angle in the NH₂ group in nicotinamide.

..... [1]