1.6: Benzene and Conjugation

Learning Objective

- Understanding and naming benzene derivatives.

Aromatic hydrocarbons, like this **benzene** ring, have unexpected chemistry.

Figure 1.6.1: benzene

We would expect to name this molecule 1,3,5-cyclohexatriene and see its double bonds react like other double bonds. However, these double bonds do not react in the same way as double bonds in a standard alkene. Observe the result of the below experiment under the appropriate reaction conditions.

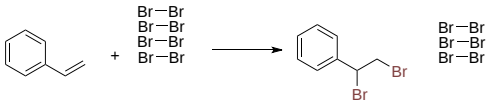

Figure 1.6.2.

This surprising stability of the double bonds in the benzene ring is not due to the cyclic arrangement of the carbon chain. Under the appropriate reaction conditions, we see the following results for adding hydrogen across the double bonds of the molecules below.

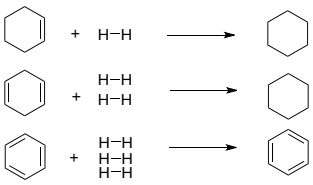

Figure 1.6.3.

Measuring the bond lengths gives the following result.

Bond Type	Bond Length (Angstroms)
Single	1.54
Double	1.34
Benzene	1.4

Therefore, the three “double bonds” of the benzene ring are not true double bonds. The electrons are shared across all of the carbons in the ring, an arrangement called **conjugation** which is better represented by the below structure.

Figure 1.6.4.

When depicting benzene rings using the double bond drawing, remember that the ring is a hybrid between two equally likely **resonance structures.**

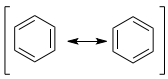

Figure 1.6.5.

Therefore both structures below would be named 1-chlorobenzene.

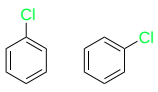

Figure 1.6.6: 1-chlorobenzene

When a benzene ring has two **substituents**, they are named based upon their position to each other rather than by numbers.

Figure 1.6.7. o is for ortho, with substituents at 1,2:o-dichlorobenzene

Figure 1.6.8. m is for meta, with substituents at 1,3:m-chloromethylbenzene

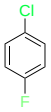

Figure 1.6.9. p is for para, with substituents at 1,4:p-chlorofluorobenzene

Practice Questions

1. What is the name of Molecule A?

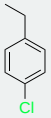

Figure 1.6.10: Molecule A

2. A benzene ring can be a substituent.

The name of this molecule is 2-phenyldecane.

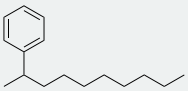

Figure 1.6.11: 2-phenyldecane

What is the name of Molecule B?

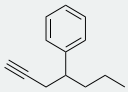

Figure 1.6.12: Molecule B

Conjugation is not limited to cyclic structures. One of the two molecules below does not react with halogen halides under standard reaction conditions. Which molecule do you predict is the more stable one? Why? What prediction would you make about the lengths of its carbon-carbon bonds?

Figure 1.6.13.

Practice Questions

1. Write the steps that you use to name a benzene derivative or a molecule containing a benzene ring as a substituent, in order, as instructions for a student who doesn't know how to do it.
2. Draw any benzene-containing molecule and go through the steps in naming your molecule.