The Aromatic Hydrocarbons

A type of hydrocarbon that looks very much like a typical cyclic hydrocarbon has such unique properties that it forms the basis of an entire class of hydrocarbons: the aromatic hydrocarbons. Originally, the name was applied to naturally occurring plant compounds with intense aromas. For many years, chemists sought to explain two contradictory properties of these compounds. Aromatic hydrocarbons have a low hydrogen–to–carbon ratio and unusual stability. A low hydrogen–to–carbon ratio is usually associated with the presence of multiple bonds. However, multiple bonds tend to make compounds more reactive, not less reactive. How could a low hydrogen–to–carbon ratio be associated with stability? This question was answered with the discovery that naturally occurring aromatic compounds are all based on the presence of a benzene ring. A **benzene** ring is a single–carbon ring with one hydrogen atom bound to each carbon atom, thus having the formula C_6H_6. **Aromatic hydrocarbons** are hydrocarbons derived from the benzene ring. All of the compounds that you have been studying up to this point are called **aliphatic compounds** to distinguish them from the aromatics. In other words, aliphatic compounds are any compounds that do not contain a benzene ring.

Chemists originally drew the benzene ring with alternating single and double bonds, as shown in **Figure 1.23A**. However, experimental observations showed that all six carbon–carbon bonds are identical in length and in other properties. The length of the carbon–carbon bonds is intermediate between a single and a double bond. Chemists then realized that benzene was a resonance hybrid of the two structures shown in **Figure 1.23B**. A *resonance hybrid* is an average of two different Lewis structures, or a structure that is between two structures.

Chemists now realize that the electrons that make up the second bond in the "double bonds" are equally shared by all six carbon atoms. Electrons that behave in this way are called *delocalized electrons*. In any compound that has one single bond between two double bonds, the electrons are delocalized. The double bonds in this combination are called conjugated double bonds. Such structures are very stable, because the electrons are not readily available for chemical reactions. Based on this information about the structure, chemists now prefer to draw the benzene ring as shown in **Figure 1.23C**. In this model, there are single bonds between the carbon atoms and a circle within the carbon ring to represent the six delocalized electrons.

benzene a cyclic, aromatic hydrocarbon, C_6H_6, in which all six carbon-carbon bonds are intermediate in length between a single and double bond; delocalized electrons are shared by all six carbon atoms

aromatic hydrocarbon compound containing only carbon and hydrogen and based on the aromatic benzene ring

aliphatic compound compound containing only carbon and hydrogen in which carbon atoms form chains and/or non-aromatic rings

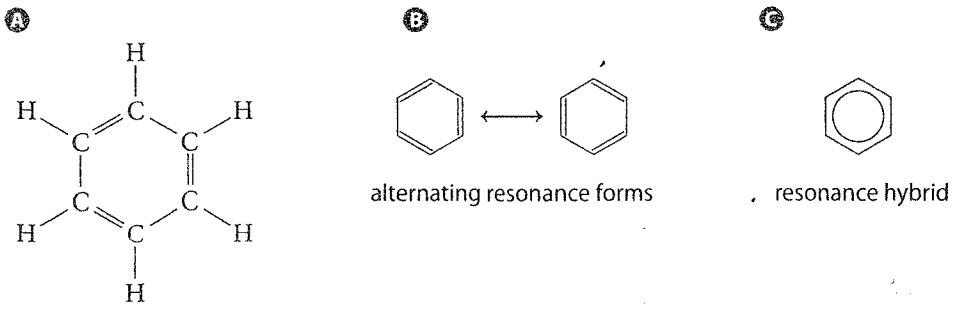
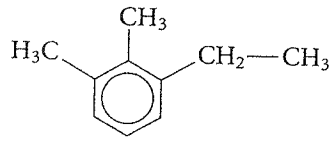
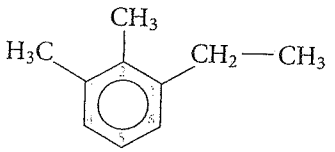


Figure 1.23 Although the double bonds portray the correct number of electrons in the bonds (**A**), they do not portray the true chemical and physical properties of benzene, which is a hybrid between two alternating resonance forms (**B**). Benzene is best represented as a circle inside a carbon ring (**C**), which models that it is a resonance hybrid.

Naming and Drawing Aromatic Hydrocarbons

Since benzene forms the basis of all aromatic hydrocarbons, the naming of simple aromatic hydrocarbons uses benzene as the root. The major steps in naming aromatic hydrocarbons are given in **Table 1.10**.

Table 1.10 Steps in Naming Aromatic Hydrocarbons

1. Identify the root. The root for an aromatic hydrocarbon is -benzene.	 The root is —benzene.
2. Identify the prefix. **a.** Determine the position number of the side groups in order to write the prefix. The carbons in a benzene ring are numbered to locate the presence of more than one side group.	
b. Prioritize alkyl side groups with six or fewer carbon atoms in alphabetical order. Then continue to number in the direction of the nearest side group.	There are two methyl groups and one ethyl group. Because ethyl comes before methyl alphabetically, it should be numbered 1. Numbering must proceed in the direction that gives the side groups the lowest numbers. Therefore, proceed counterclockwise from the ethyl group.
c. Write the prefix as you would for any other hydrocarbon.	The prefix is 1-ethyl-2,3-dimethyl-.
3. Name the compound. Combine the prefix and root to name the compound. Note that there is no hyphen or space between the prefix and the root.	The compound is 1-ethyl-2,3-dimethylbenzene.

To draw aromatic hydrocarbons with side groups that have six or fewer carbon atoms in any given chain, draw the benzene ring, and then add the side groups as indicated. If a benzene ring is attached to a single hydrocarbon chain that is larger than the benzene ring itself (more than six carbon atoms), the benzene ring is considered to be the side group. In such cases, the attached benzene ring is called a **phenyl group**. Name the compound according to the steps for naming aliphatic hydrocarbons, and then name the benzene ring as a phenyl group, just as you would have named an alkyl group such as "methyl." The Sample Problems and Practice Problems that follow will help you apply the naming and drawing of aromatic hydrocarbons.

phenyl group term used for a benzene ring that forms a substituent group on a hydrocarbon chain

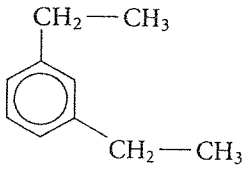
Sample Problem

Naming Aromatic Hydrocarbons

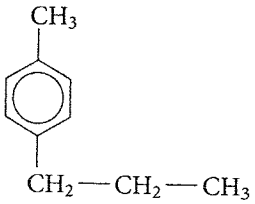
Problem

Name the following hydrocarbons.

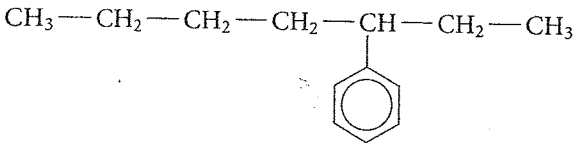
a.



b.



c.

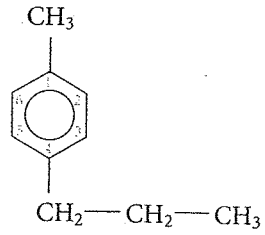
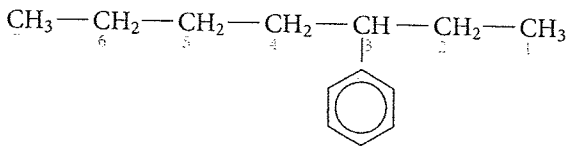


What Is Required?

You must name three aromatic hydrocarbons.

What Is Given?

You are given the structural formulas of the hydrocarbons.

Plan Your Strategy	Act on Your Strategy
a. Identify the root.	The hydrocarbon chains have fewer than six carbon atoms, so the root is -benzene.
Identify the prefix.	Both side groups have two carbon atoms, so they are both ethyl groups. Either ethyl group can be chosen to be on carbon atom 1. Counting goes in the direction that will give the second group the smaller number. Therefore, the prefix is 1,3-diethyl-.
Write the name.	The compound is 1,3-diethylbeneze.
b. Identify the root.	The hydrocarbon chains have fewer than siz carbon atoms, so the root is -benzene.
Identify the prefix.	The side group at the top of the benzene ring is a methyl group. The side group with three carbon atoms is a propyl group. The methyl group comes first alphabetically, so it is on carbon atom 1. The propyl group will be on carbon atom 4 regardless of the direction of the numbering. Therefore, the prefix is 1-methyl-4-propyl-. 
Write the name.	The compound is 1-methyl-4-propylbenzene.
c. Identify the root.	The hydrocarbon chain has seven carbon atoms, so the benzene ring is a side group. There are no multiple bonds in the main chain, so the root and suffix are -heptane.
Identify the prefix.	Benzene is the side group, so it is a phenyl group. The phenyl group is nearer the right end of the chain. Numbering goes from right to left and the side group is on carbon atom 3.  The prefix is 3-phenyl-.
Write the name.	The compound is 3-phenylheptane.

Check Your Solution

In each case, the root, prefix, and suffix correctly describe the structure.

Sample Problem

Drawing Aromatic Hydrocarbons

Problem

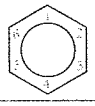
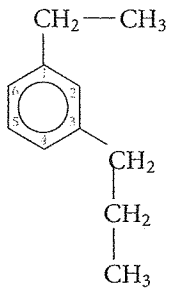
Draw the structure of 1-ethyl-3-propylbenzene.

What Is Required?

You must draw the structure of a compound.

What Is Given?

You are given the name of the compound.

Plan Your Strategy	Act on Your Strategy
a. Identify the root.	The root is benzene, so the structure is based on a benzene ring. 
If there is more than one side group, number the carbon atoms in the ring.	There are two side groups, so the ring must be numbered. 
Identify the prefix, and draw the side groups.	The prefix is 1-ethyl-3-propyl-, so there is an ethyl group on carbon atom 1 and a propyl group on carbon atom 3. 

Check Your Solution

An ethyl group is on carbon atom 1 and a propyl group is on carbon atom 3 of the benzene ring, so the structure is correct.