Organic Compounds: Drawing Structures

Objective: To gain familiarity with organic structures and bonding through the use of drawing molecule structures.

Why are there so many organic compounds? The reason is that carbon atoms have the ability to link to other carbon atoms (concatenate) to produce chains or rings of almost infinite size. Other elements do not concatenate nearly as well, due to such factors as poor orbital overlap and lone pair-lone pair electronic repulsions. Other elements can also combine with carbon to form hetero-species, hydrogen, oxygen, nitrogen, sulfur and the halogens are most prevalent.

The purpose of this exercise is to help you visualize the structure of organic compounds by drawing structural formulas of the more common organic types. You should consult your textbook for a more complete treatment of the nature and formation of organic systems.

1. Draw sawhorse structures of the straight-chain alkanes from methane through decane. Note that each carbon atom can rotate about its respective carbon-carbon bond.
   a) Sketch the methane molecule showing the tetrahedral nature of the carbon atom.

   b) Using sawhorse line structures, sketch the configuration of ethane through decane. You may omit the hydrogens from the sawhorse structures.

   c) Sketch the sawhorse structure of butane when you orient the butane model so that the methyl groups are anti- to one another (with an angle of 180° between them).

   d) Now sketch the sawhorse structure of butane when you orient the butane model so that the methyl groups are at an angle of 120°.

   e) Next, draw a sawhorse structure of butane when you orient the butane model so that the methyl groups are at an angle of 60°.

   f) Finally, draw a sawhorse structure of butane when you orient the butane model so that the methyl groups are eclipsed or at an angle of 0° to each other.

   g) Explain which configuration is the most stable configuration for butane.
2. Draw sawhorse (line skeleton) structures of the five structural isomers of the hexane molecule, \( \text{C}_6\text{H}_{14} \). Under each structure, give the correct IUPAC name for each structure.
   a)  
   b)  
   c)  
   d)  
   e)  

3. Draw sawhorse (line skeleton) structures for each of the following unsaturated hydrocarbons:
   a) 1-hexene  
   b) trans-3-hexene  
   c) cis-3-hexene  
   d) cis-trans-2,6-octadiene  
   e) 1-pentyne  
   f) 2-pentyne  

4. a) Draw a ring structure of the aromatic compound benzene, \( \text{C}_6\text{H}_{14} \). What accounts for the observed facts that measurement of C-C bond distance in benzene shows that all are the same length (1.397 Å) and that the C-C bond angles are all 120°?

   b) Benzene was at one time used extensively as a solvent. However, since it has been found to be carcinogenic, it has largely been replace by toluene. Toluene contains an aromatic ring substituted with a methyl group and has a molecular formula, \( \text{C}_7\text{H}_8 \). Draw a possible structure for toluene. Do you think this material would have a higher or lower boiling point than benzene? Explain.
5. Draw structures of the following aromatic hydrocarbons.
   a) chlorobenzene          b) 1,2-chlorobenzene          c) 3-nitrobenzene
   d) 4-bromobenzoic acid    e) para aminobenzoic acid    f) 4-nitrophenol
   g) 1,3,5-trimethylbenzene h) 2,4,6-trinitrotoluene   i) meta-zylene

j) Draw two resonance forms for naphthalene using the Kekule type structures.

k) There are three dichlorobenzene isomers. Draw them. Which one would you expect not to have a dipole moment? Explain.

l) Draw the structure for cyclobutyne. Would you expect the cyclobutyne structure to be a stable compound? Explain.

6. Draw structures for the following functional group compounds:
   a) 2-butanone                  b) 2-methyl-2-propanol            c) ethylpropanoate
   d) 1-aminohexane or hexanamine e) 2-bromopentane            f) butanoic acid
g) Ethyl alcohol is miscible with water in all proportions, whereas diethyl ether is only slightly soluble in water. Draw structures of the two molecules and explain.

h) Draw structures for acetone (2-propanone) and formaldehyde (methanal). What are the bond angles around the C=O carbon atom in each of these compounds? Would you expect these compounds to be soluble in water? Explain.

7. Draw structural formulas for the following:
   a) hexanal
   b) 3-chloropentane
   c) benzoic acid
   d) methylethylether
   e) ethylethanoate
   f) 3-pentanone
   g) 2-aminobutane
   h) 2-propanol
   i) butanamide
   j) cis-3-pentene
   k) 3-pentyne
   l) cyclohexane