1.1: Organic Structures Procedure and Report Sheets

Organic Structures

It is very important to **build** the models as described in order to gain the visual experience with the molecules and their geometry. In Chemistry 106 it is expected that the student will have the basic understanding of Lewis Structures and VSEPR Theory from Chemistry 104 and be able to relate the physical structures and shapes to physical properties by applying intermolecular force theory between molecules from Chemistry 105. This lab is designed to allow you to review these concepts.

Because there is no prelab during week 1, the lab is worth 25 points total, 0.5 point for each numbered question unless noted.

Part A. Alkenes

Cis-Trans (Geometric) Isomerism

Alkenes are hydrocarbons containing one or more double bonds. They are referred to as *unsaturated* hydrocarbons. They are named according to the longest continuous chain of carbon atoms, adding –ene to the end, and using a number to indicate the position of the double bonds, if necessary. The simplest alkene is ethene, CH_2=CH_2, also known by the common name, ethylene.

First, we will review alkanes.

Make a model of butane, C_4H_{10}. The structure is shown below in Figure 1.1.1 using the line drawing and the structural formula.

Figure 1.1.1: Skeletal and structural formula for butane

Rotate the ***single*** carbon-carbon bonds such that the end methyl (CH_3) groups are on opposite sides of the center carbons.

Now, rotate the ***single*** carbon-carbon bonds such that the end methyl groups are on the same side of the center carbons.

1. What are the bond angles and molecular geometry around each of the carbon atoms?
2. Would the structures you have produced in parts a and b be considered isomers of one another? Explain your answer. (use a complete sentence)

Now **make a model** of cis-2-butene (in which both methyl groups are on the same side of the double bond). The structural formula for cis-2-butene is shown below:

Figure 1.1.2: Skeletal structure of cis-2-butene.

3. What is the approximate bond angle **and** molecular geometry around the 2 middle carbon atoms? (You do not need to memorize each specific bond angle in individual molecules. Think about the general geometry of C=C double bonds.)

4. Try to rotate or “spin” the middle carbon atoms. Is this possible with the double bond? Describe what you see. (1 point)

Make a model of trans-2-butene (the end methyl groups are on the opposite sides of the carbon-carbon double bond).

5. Draw the structural formula for trans-2-butene.

6. What are the approximate bond angles and molecular geometry around the double bonded carbons?

7. Can your trans-2-butene model be converted back into the cis-2-butene model without breaking bonds? Describe what happens when you try. (1 point)

The cis- and trans-2-butenes are called **geometric isomers.**

For numbers 8-11, you will indicate whether each of the following compound pairs are geometric isomers or structural isomers or not isomers at all.

Write the names for the compounds under each formula.

If they have the same names, then they **are the same molecule and are not isomers**. (**2 point each**)

8. For the following 2 structures:

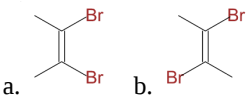
   a. CH_3 - CH = CH - CH_3 b. CH_3 - CH_2 - CH = CH_2

   Write the names:

   Are these structures isomers?

   If so what type?

9. For the following molecules:

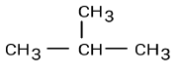


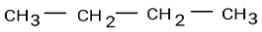
   Write the names:

Are these structures isomers?

If so what type?

10. For the following 2 molecules:



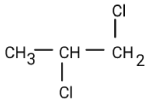


Write the names:

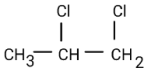
Are these structures isomers?

If so what type?

11. For the following 2 molecules:



and



Write the names:

Are these structures isomers?

If so what type?

Part B. Aromatic Hydrocarbons and Resonance

Construct a model of the benzene molecule from the structural formula.

It can be a struggle with the longer bonds to get them to fit the 3 double bonds in between the 3 single bonds.

Benzene is probably the most recognizable example of an aromatic hydrocarbon, it appears to have alternating double and single bonds, in a “ring or cyclic” structure, and is a specialized alkene. However, it has been determined that the structure is not the alternating double/single bonds (which is the Lewis Structure you constructed), but it is actually a series of 6 equal covalent bonds that are about longer than the length of a single bond, and shorter than a double bond (shown in the center structure below).

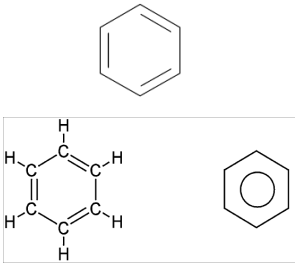


Figure 1.1.3: The three depictions of benzene.

Three different representations of benzene are shown above in figure 1.1.3, the stick model, the complete Lewis structure and the "ring" version. The circle in the ring reflects this and distinguishes the "aromatic ring" from a cyclohexane ring. It is possible to draw the Lewis Structure with the double bonds between the other carbons, this is called "resonance". (Review: Drawing Lewis Structures from Chemistry 104) Benzene compounds are the basis of a field of Organic Chemistry called "Aromatic Compounds".

The following questions are designed to guide you through understanding the structure and the related physical properties. Review Intermolecular forces (IMFs).

Study the structure you built and the structures drawn above.

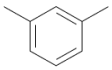
12. What are the bond angles and the geometry of each of the carbons in benzene?

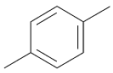
    (Hint: They are all the same.)

13. Draw the structural formula for methylbenzene.

14. What is the common name of this molecule?

Name the following structures use the **IUPAC** name.

15. 

16. 

17. Look up the boiling point of benzene and the boiling point of water.

Explain the difference in boiling points of these two compounds using the concept of intermolecular forces. (It is helpful to list the IMFs for each.)

    Use your own words for full credit. (2 points total).

Part C. **Alkynes**

Alkynes are hydrocarbons containing one or more **triple** bonds. They are also referred to as unsaturated. They are named according to the longest continuous chain of carbon atoms using a number to indicate the position of the triple bonds, if necessary. The simplest alkyne is ethyne, CHCH, also known by the common name, acetylene.

18. Construct a model of 1-propyne and draw its structural formula here.

19. What is the molecular geometry **around all 3 of** the carbon atoms

Part D. **Functional Groups**

The behavior of organic molecules is governed by the presence of ***functional groups***, which are combinations of atoms that act as chemically reactive sites on the molecule. Compounds with the same functional group will have many similar physical properties and undergo similar chemical reactions. Double and triple bonds are also considered to be ***functional groups***.

Build the following molecules and answer the questions based on the structures.

Alcohols

Alcohols have the general formula R-OH, where R is any alkyl group and the OH is called a **hydroxyl group**. Note: since the OH is bonded covalently to a carbon, it is not an ionic compound, therefore it is not a hydroxide ion.

Construct a model for 1-propanol, C_3H_7OH.

20. Draw the structural formula for 1-propanol, C_3H_7OH. (The common name is propanol, or propyl alcohol)

21. What is the molecular structure (molecular geometry) on each of the carbon's and on the oxygen?

Construct a model for 2-propanol, C_3H_7OH.

22. Draw the structural formula for 2-propanol, C_3H_7OH. (The common name is isopropanol, or isopropyl alcohol).

23. Write the definition of “structural isomers” here.

24. Are 1-propanol and 2 propanol structural isomers of each other?

Ethers

Ethers have the general formula R-O-R', where R,R' = alkyl groups.

25. Draw the structural formula of dimethyl ether, CH_3OCH_3.

26. Construct a model of ethanol CH_3CH_2OH, then draw the structural formula here:

27. Look up and list the boiling points of dimethyl ether and ethanol.

28. a. List the intermolecular forces between the dimethyl ether molecules.

(Hint: draw 2 molecules to see the IMFs.)

b. List the intermolecular forces between the ethanol molecules.

(Hint: draw 2 molecules to see the IMFs)

29. Explain the difference in the boiling points using the concept of intermolecular forces. Use your own words for full credit.

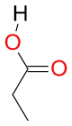
There are many types of ***Functional Groups*** that are listed in your text, most of which we will study during this course. Some are oxygen containing compounds: aldehydes, ketones, carboxylic acids and esters. Some are nitrogen containing compounds called amines. Some have both oxygen and nitrogen and are called amides.

Look up the general formula of aldehydes and ketones, carboxylic acids, ethers and esters.

Look up the general formula of amine and amides.

Name the **functional group only** in the following compounds. (You do not need to name the compound)

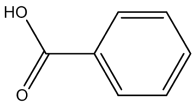
30. 

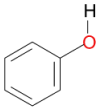
31. 

32. 

Match the following compounds with their common names:

Choices: Trinitrotoluene(TNT), para-Xylene, aniline, phenol, benzoic acid, benzaldehyde, toluene, ethylbenzene.

33. 

34. 

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