3.2: Chirality Procedure and Report Sheets

Learning Objectives

- To learn the isomer family tree.
- To use models to distinguish between chiral and achiral systems.
- To define and illustrate enantiomers and diasteromers.
- To learn how to represent these systems in two-dimensional space using a chemistry drawing program.

Materials:

Molecular Model Kit

Helpful Hints and Resources

- You will build the molecules, and use the structures to answer the questions in this lab report. You are asked to draw structures on this form or you may be directed to draw structures on your scratch sheet, be sure to read each question carefully.
- You will need to recall the concepts of Lewis Structures and the VSEPR (Valence Shell Electron Pair Repulsion Theory)

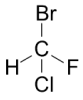
Procedure: (0.5 points per number question unless noted)

Part I. Stereocenters

1. Carbon atoms form four bonds in organic chemistry. Draw a picture of methane.

   (Do not use wedges or dashes in this compound in your drawing. We will introduce them later in this lab.)

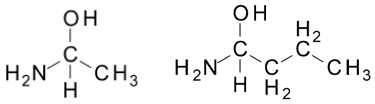
2. Stereocenters are carbon atoms that are bound to 4 different groups. Build the following molecule.



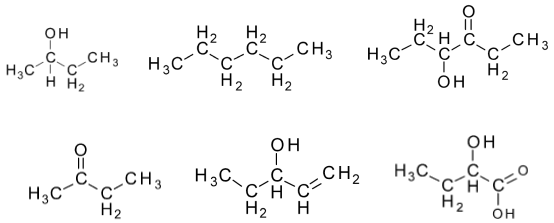
3. Now build the following molecule as well. Is the carbon in the following molecule a stereocenter?

4. Draw a chiral carbon, that is a carbon attached to four different single atoms. Be sure your compound is a complete and correct Lewis structure.
5. The carbon you just drew is a stereocenter. Carbons that have double bonds are not stereocenters. Why is this statement true?

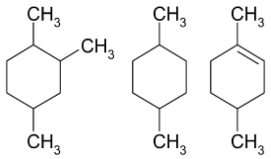
6. List the four different groups around the following carbon stereocenters in each molecule in the space below each molecule.



6. Number all the carbons from left to right starting with #1. List which carbons in the following molecules are stereocenters. For instance, in the molecule above there are two carbons, C1 and C2. C1, the carbon connected to the hydroxyl, is a stereocenter and C2, the other carbon, is not. If there are none write none below the molecule. (3 points)



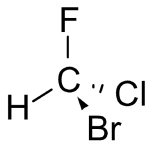
7. Build and then draw 1-bromocyclohexane and build and draw 1-bromo-2-chlorocyclohexane.
8. Notice 1-bromocyclohexane does not have a stereocenter because it is symmetrical. Whereas, 1-bromo-2-chlorocyclohexane is does have two stereocenters. Which carbons are stereocenters? (describe using words which C you mean)
9. Number the carbons from the top of the hexagon moving clockwise. Do not include the methyl groups in your numbering. List which carbons that are stereocenters. If there are none, write none below the molecule. (1.5 points)



10. Chiral molecules are optically active. In one paragraph of complete sentences explain what this means? (You may use the internet or your book for help.) (1 point)

Part II. Enatiomers

1. Build a molecule of methane with the models. What is the VSEPR geometry of methane?
2. Does the molecule below have a stereocenter?



3. Place the molecule in front of a mirror. Using the models build the image you see in the mirror. Draw a picture here.
4. Place one model on top of the other as if one was riding piggy-back on the other. When you do this keep the white, black, and red atoms as close as physically possible to the other white, black, and red atoms respectively. Are they superimposable? What is different about these two molecules?

5. These molecules are enantiomers. They have the same molecular formula, the some connectivity, but are spatially arranged about the tetrahedral atom differently. Enatiomers – stereoisomers that are nonsuperimposable mirror images. Switch the

positions of the orange and green atoms in one of these molecules. How are these two molecules now related? Are they still mirror images of each other?

6. Build a model of ethanol. Draw a picture of it below. (1.5 points)

   Using the models build the mirror image of this molecule. Piggy-back the two molecules in the same fashion as you did before.

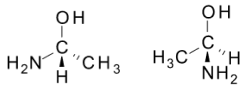
   - Do they overlap completely?
   - Does this molecule have one or more stereocenters (chiral atoms)?
   - Are these molecules enantiomers? Why or why not?
   - Does having a mirror image mean you have an enantiomer?

7. Build the following molecule: 1-chloroethanol. Draw a picture of it below.
8. Using the models create the mirror image of this molecule. Piggy-back the two molecules in the same fashion as above. (1 point)

   - Do they overlap completely?
   - Does this molecule have one or more stereocenters (chiral atoms)?
   - Are these molecules enantiomers? Why or why not?

- Use what you see to explain what enantiomers are?

9. Make the following molecules exactly as shown. Be sure that the wedges and dashed bonds are in the right order. Are they enantiomers or the same molecule?



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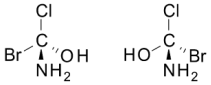
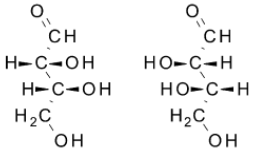


Part III. Molecules with Two or More Stereocenters

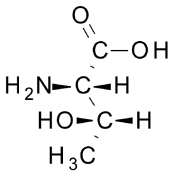
1. Make the models below. Remember that solid wedges are pointing at you and dashed ones are pointing away from you. These will look very different from the 2D picture. (It is sometimes easier to see if you leave the H's off the hydroxyl groups.)



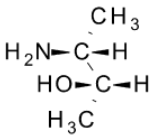
> Be sure to hold one up to a mirror and check to see if the other one looks identical to the reflection.

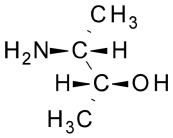
Do you have mirror images? If not be sure to check with your instructor.

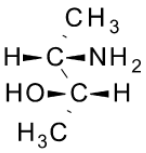
2. How many chiral centers does each molecule have? By number, which carbons are chiral?
3. Are these two molecules enantiomers?
4. At this point you might be asking yourself, why are these molecules different. To prove that they are unique molecules try to piggy-back them. Are they superimposable?
5. Can you spin them in any manner to make them superimposable, without breaking any bonds?
6. Go back to the positions you had at the end of step 1. Switch hydroxyl and hydrogen on carbon #3 on one of the molecules. (You are breaking bonds in this step.) (0 points)
7. Now you do not have mirror images. Therefore, these molecules are no longer enantiomers. However, you do still have two chiral centers. These molecules are now examples of diastereomers. Diastereomers are stereoisomers that are not mirror images. (0 point)
8. Here is the amino acid Theronine. Build this molecule.

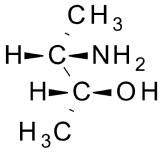


9. Determine which of the following 3-amino-2-butanol isomers are pairs of enantiomers and which are pairs of diastereomers. Be sure to compare all 4 structures with all the other structures. (1 point)

1. 

2. 

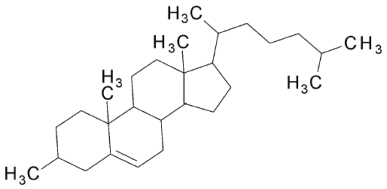
3. 

4. 

List your answer below.

Part IV. Chirality in Biochemistry

1. There are many examples of chiral molecules in biochemistry. Below is a picture of cholesterol. How many stereocenters does this molecule have? Circle them on the molecule below.(1 points)



An amazing fact about cholesterol is that our bodies only have one of its isomers.

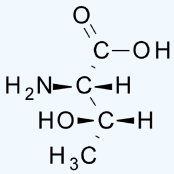
The formula for determining total number of isomers is as follows.

$$2^{x} = \text{number of possible isomers} \tag{3.2.1}$$

where x = Number of stereocenters.

Example 3.2.1

How many isomers does Theronine have?



Solution

Theronine has 2 stereocenters.

$$2^2 = 4 \text{ possible isomers} \tag{3.2.2}$$

2. How many isomers of cholesterol exists?

3. Ibuprofen is created as a racemic mixture. In one paragraph of complete sentences explain what this means? (You may use the internet or your book for help.) (1.5 point)
