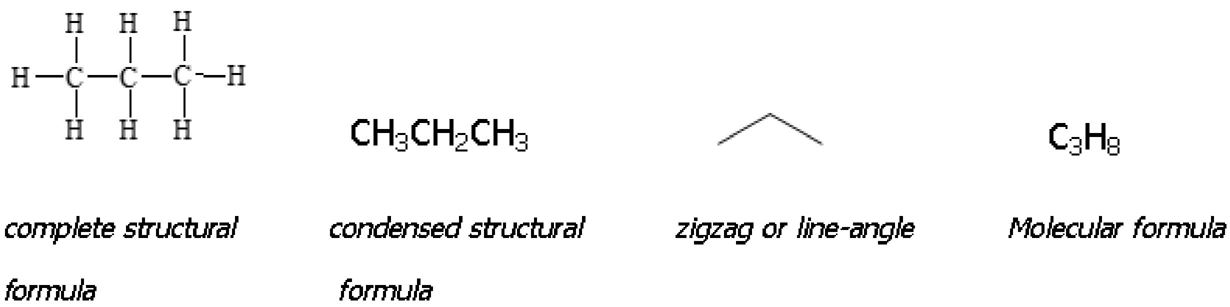
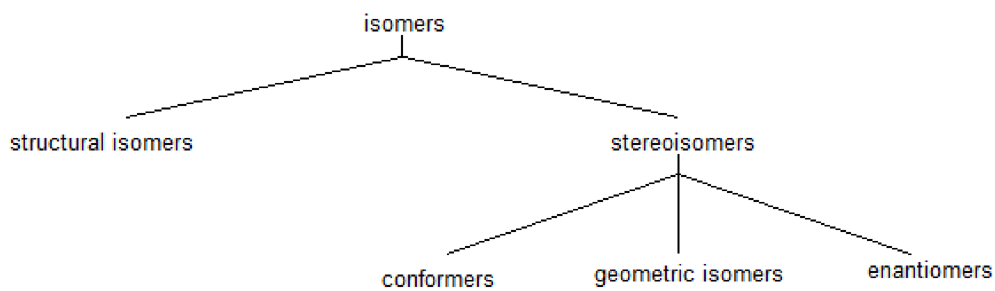
Isomers lab activity

prelab: [3 points]



source: of the above figure. Skim: **Section 1: Purpose and Summary** ; the link is also, the source of this lab activity, where there are minor revisions. Course focus will be on structural and geometric isomers. Also,



source of the above figure.

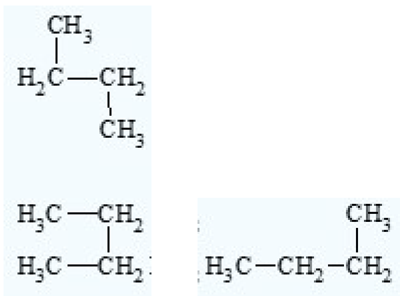
Based on the preceding links, describe:

- Structural formula
- Structural isomers
- Geometric isomers

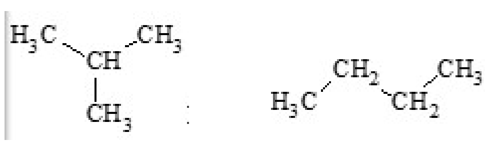
lab: bring your chromebook to class on the day of the lab, so you can access the below links while doing the lab activity. The purpose of the lab is to use an organic molecule kit to build various organic chemicals and visualize these organic molecules to understand the concept of isomers. [23 points]

Part 1: Alkanes [3 points]

4. Using your model for butane, rotate the bonds and twist the molecule. There is free rotation around single bonds, so molecules are constantly twisting, rotating, and changing their **conformation**. It is important to understand that this type of motion is happening constantly in any given molecule. By looking at the following structures, you should be able to recognize that they are equivalent and represent the same molecule. They are NOT isomers of each other!



5. Construct a model for isobutane. (The IUPAC name for isobutane is 2-methylpropane.) Compare this with your model for butane from step 4. Note that butane and isobutane cannot be interconverted without breaking the bonds. Thus, they represent distinct molecules with different properties. Draw the complete structural formula and the condensed structural formula for isobutane in the worksheet below.

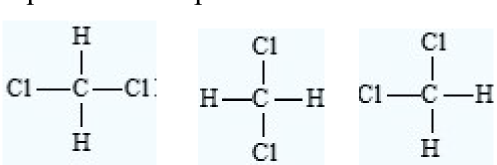


Isobutane *n-butane*

7. Now, consider pentane, C_5H_{12}. There are three isomers for pentane. Construct a model for each isomer. For each isomer, write the condensed structural formula and IUPAC name. Look up the molar mass, melting point, boiling point, and density for each isomer and record below.

Part 3: Haloalkanes [3 points]

2. Again, starting with a model of CH_4, replace two hydrogen atoms with chlorine atoms. Are there different isomers possible for this formula? Given the structures below, are these molecules isomers or equivalent? Explain.



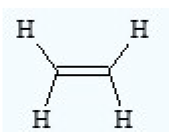
4. Starting with your model of ethane, make a model of chloroethane, CH_3CH_2Cl. Again, do this by removing one of the hydrogen atoms and replacing it with a chlorine atom. Are there different isomers possible for this molecule? Explain. Draw the three-dimensional structure of this molecule.

5. From your model in step 4, replace another hydrogen atom with a chlorine atom. There are two possible locations for the second chlorine atom: on the same carbon as the first chlorine atom, or on the other carbon atom. Thus, there are two isomers possible for the molecular formula $C_2H_4Cl_2$. Make models of both isomers and compare them.

Notes: There are only two isomers possible for this molecule. There are five possible locations for the second chlorine atom. But since two of the positions are equivalent to each other (free rotation around the bonds), placing the chlorine at either of these two positions results in the same molecule. Similarly, the other three positions are equivalent to each other, so placing the chlorine at any of these positions will give you the same molecule. Even though there are five possible locations for the chlorine, there are only two types of positions, hence, only two isomers are possible.

Part 4: Geometric isomerism [4 points]

1. Starting with a model of ethane CH_3CH_3. Remove two of the hydrogens. Replace the hydrogens with a second bond between the two carbons using one of the longer bonds in the model kit. This new compound is called ethylene. It is sometimes written as $H_2C{=}CH_2$. It has a carbon-carbon doublebond.



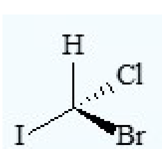
2. Remove a hydrogen and replace it with a chlorine. This formula is CH_2CHCl and is called chloroethylene. The double bond restricts where the chlorine can be and since the molecule cannot be turned around in any geometric position, there is only one way that chloroethylene can be constructed.

4. Swap one of your chlorines with a hydrogen from the second carbon in 1,1-dichloroethylene ($C_2H_2Cl_2$). There are two possible ways to construct this molecule. Make models of the isomers and compare them. Which one is *cis* and which one is *trans*?

5. Construct models of the *cis* and *trans* isomers of 2-pentene (C_5H_{10}). See how these two compounds are geometrically bonded differently. They have slightly different chemical properties and chemical reactivity. Draw their structures in the worksheet below.

Part 5: Optically active centers [5 points]

1. Starting with a model of CH4, replace the 1st hydrogen atom with a chlorine atom, a 2nd hydrogen with a bromine atom, and a 3rd hydrogen with an iodine atom. The formula for this is CHClBrI.



2. Construct a second model of CHClBrI that is identical to the first one. You should be able to see that the two models can be superimposed on one another.

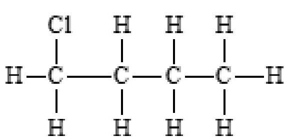
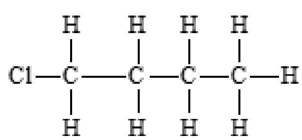
3. With one of your models of CHClBrI, swap any two of the atoms. Alternatively, make mirror image isomers. For example, the H and Cl can be exchanged with one another but do not change the Br and I.

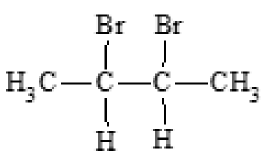
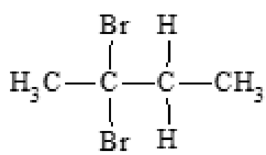
4. Compare your two models of CHClBrI. Note that these compounds are now different. It is impossible to superimpose one upon the other. They are, in effect, mirror images of each other relative to the central carbon atom.
Notes: There are only two isomers possible for this molecule. Convince yourself of this by making various models of the different possibilities and noticing which ones are the same. Even though there are four different atoms attached to the central carbon, only two isomers are possible.

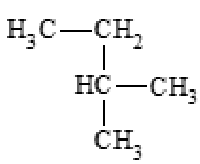
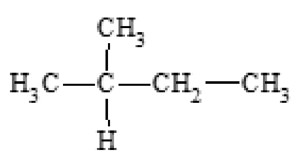
5. Look down the bond that has the highest priority. In CHClBrI, this would be the carbon-iodine bond (carbon is bonded to the element with the highest atomic number). Assign priority to the remaining 3 bonds. In this case, the order would be C-Br > C-Cl >C-H. Draw an arrow in a circle around the 3 bonds. If the arrow is clockwise, it is an *R*- configuration. If it is counterclockwise, it is an *S*- configuration. Assign the *R*- and *S*- configuration to your two isomers.

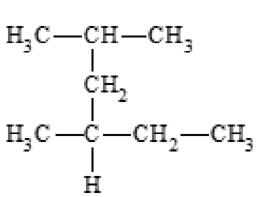
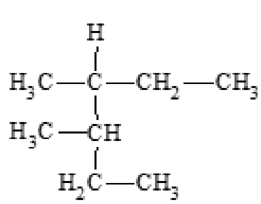
Post Lab Questions: [4 points]

For each of the following pairs of molecules, state whether they are isomers, identical, or neither. Briefly explain your reasoning in each case.

1.  and 

2.  and 

4.  and 

5.  and 

Addendum [4 points]

1. Build the most stable form of n-butane, then sketch it; background:
   - Steric strain has a role in the shape of some molecules, where a Newman projection might aid in visualizing the molecule's shape; e.g. n-butane.

2. Build the most stable form of cyclohexane, then sketch it; basis / rationale ?

3. Build / sketch two structural isomers of cyclohexane; e.g. cycloalkane (relative stability) and alkene

4. Build / sketch the conformation(s) (i.e. molecule's shape) of cyclohexane versus benzene. How do these compounds have similar versus different conformations ? basis / rationale ?