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| Isomers of Hydrocarbons Laboratory |
| C5.8A & C5.8B |
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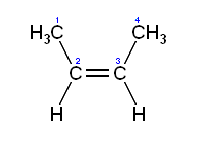
Isomers of Hydrocarbons Laboratory

**Background:**

Two things about carbon make it uniquely suited to forming a vast number of compounds. First, the bonds that carbon forms with itself and hydrogen are relatively strong, making hydrocarbons relatively stable. Second, carbon can form four bonds allowing for a wide variety of possible chemical combinations. This variety may be greater than one would first think based on molecular formula, because isomers must be included in the list of compounds that can be formed. ***Isomers*** are compounds that have the same chemical formula, but different structural formulas. The isomers of any given chemical formula will have different chemical and physical properties, so it is important to understand the distinction.

An example may help. The compound C10H22 is an alkane because it conforms to the general formula CnH2n+2 where n is a positive integer. It can take on the structure of n-decane. However, 2-methylnonane also has the formula C10H22. Indeed, there are seventy five isomers of C10H22.

When dealing with compounds that have multiple carbon-carbon bonds, another factor must be taken into account. The additional pi-bond or bonds formed will not allow for rotation. Therefore, if the compound has side groups on either side of the double bond cis and trans isomers must be considered.



**Figure** : Trans-2-butene (Wikipedia, June 2008)

For example there are four isomers of butene, C4H8, two of which are cis-2-butene and trans-2-butene. Each of these has its own unique properties as a result of the distribution of the atoms in the compound.

**Figure** : Cis-2-butene (Wikipedia, June 2008)

In constructing models of isomers, it is important to use the correct bond angel. For any given central atom, if four atoms are bonding to it, Valence Shell Electron Pair Repulsion theory (VSEPR) indicates that the bond angle should be 109.5˚. If a central atom has three atoms bound to it, VSEPR indicates that the bond angle will be 120˚. When only two atoms are bound to a central atom, the bond angle will 180˚. Non-bonding electron pairs will not be dealt with in this activity.

In this activity three types of hydrocarbons will be dealt with: alkanes, alkenes and alkynes. To determine if you are dealing with an alkane, alkene or alkyne, use the following definitions. Alkanes are hydrocarbons in which all the carbon-carbon bonds are single, that take on the general formula CnH2n+2. Alkenes are hydrocarbons in which at least one of the carbon-carbon bonds is double, that take on the general formula CnH2n. Alkynes are hydrocarbons in which at least one of the carbon-carbon bonds is triple, that take the general formula CnH2n-2. In all these examples n is a positive integer. For alkenes and alkynes the focus will be only those that have one multiple bond in the formula, and for alkanes, alkenes and alkynes the isomers will be of the non-cyclic variety.

**Purpose:**

In this activity the student will be able to:

* Construct the isomers of alkanes containing up to six carbons.
* Construct the isomers of alkenes and alkynes containing up to five carbons.
* Draw the structural formula of the compounds they have constructed.
* Name the compounds they have constructed.

**Materials:**

Molecular model kits, one per group.

**Procedure:**

Use your knowledge of molecular structure, and the model kits to construct all of the isomers for the formulas listed. Draw the structural formula for and give the name of each isomer. Answer any questions as you proceed.

It may be helpful to follow the steps listed at <http://www.chemhelper.com/drawingisomers.html> .

1. Draw and name the two structural isomers of C4H10.
   1. Is this an alkane, alkene of alkyne?
2. Draw the three structural isomers of the alkane that has five carbons in it.
   1. Place the name of each beneath its structural formula.
3. Draw and name the two structural isomers of C4H6.
4. Draw and name the four structural isomers of the alkyne that has five carbons in it.
5. Draw and name the four structural isomers of the alkene that has four carbons.
6. Draw and name the five structural isomers of C5H10.
7. Draw and name the five isomers of C6H14.

Teacher Companion Notes to Isomers of Hydrocarbons Laboratory

**Safety Notice:**

It is assumed that the instructors presenting this material are trained in appropriate safety procedures in the chemistry laboratory, and that the students under their tutelage have been completely informed of the specific precautions to be undertaken for this laboratory and the general behaviors appropriate to the chemistry laboratory. It is further assumed that instructors have familiarized themselves with the Material Safety Data Sheets (MSDS) for all the chemicals present in this laboratory, observe all the precautions that the MSDS indicates and have a copy of the MSDS on hand during the investigation. Additionally, it is assumed that all appropriate safety gear necessary to an adequately equipped chemistry laboratory is present in the room in which the laboratory is taking place, the instructor and students are familiar with its proper use, and that this equipment is in excellent functioning order.

It is the instructor’s sole responsibility to insure the safety of the students and staff in the chemistry laboratory, and the individuals in the surrounding areas. It further is the instructor’s sole responsibility to be fully informed of the regulations pertinent to their locale and to follow those regulations completely. This applies to the proper use and disposal of chemicals in the laboratory, equipment in the laboratory, and training of the instructor and students as to procedures in the laboratory.

An excellent resource for MSDSs is Flinn Scientific: <http://www.flinnsci.com/search_MSDS.asp> .

The class room teacher takes sole responsibility for the safe conduction of this laboratory.

**High School Content Expectations:**

**C5.8A:** Draw structural formulas for up to the carbon chains of simple hydrocarbons.

**C5.8B:** Draw isomers for simple hydrocarbons.

Note: both of these are Michigan Merit Exam content expectations.

A thorough coverage of the IUPAC nomenclature of hydrocarbons is advised before performing this activity.

The compounds drawn in this exercise should be:

1. n-butane & 2-methylpropane
2. n-pentane, 2-methylbutane & 2,2-dimethylpropane
3. n-1-butyne & n-2-butyne
4. n-1-pentyne, 4-methyl-1-butyne, n-2-butyne, 3-methyl-2-butyne
5. n-1-butene, 2-methyl-2-propene, trans-2-butene & cis-2-butene
6. n-1-pentene, 2-methyl-1-butene, 3-methyl-1-butene, n-2-pentene & 1-metthyl-2-butene
7. n-hexane, 2-methylpentane, 3-methylpentane, 2,2-dimethylbutane, 2.3-dimethylbutane.

Useful resources:

* <http://webhost.bridgew.edu/fgorga/Stereochem/default.htm>
* <http://www.chemhelper.com/drawingisomers.html>

**Bibliography:**

"Butene." *Wikipedia, The Free Encyclopedia*. 3 Jun 2008, 22:52 UTC. Wikimedia Foundation, Inc. 4 Jun 2008 <<http://en.wikipedia.org/w/index.php?title=Butene&oldid=216946517>>.

**Contact Information:**

Please contact the author if it is discovered that any of the material in this assignment is inaccurate, or if you have any suggestions for its improvement. [KingChemistry@comcast.net](mailto:KingChemistry@comcast.net) .

**Please Provide Feedback:**

If this material was useful in improving student understanding of the content, please let me know. If this material could use revision to improve student learning, again, please let me know. [KingChemistry@comcast.net](mailto:KingChemistry@comcast.net) .