Exp #08: ORGANIC MOLECULES

Introductory Chemistry

Name: _____

Student ID: _____

Chem 10 — De Anza College

Goals

- Explore different ways organic molecules are represented and understood.
- Distinguish between structural isomers, conformers, and stereo isomers.
- Become familiar with common functional groups.

Equipment

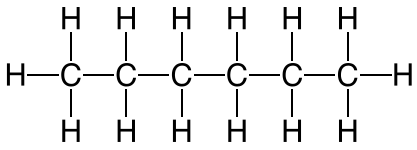
- Molecular Model Kit.

Objective

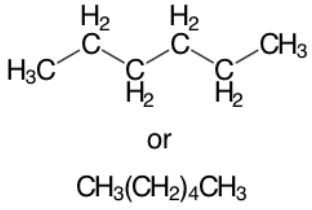
- Determine the relationship between three sets of molecules.

Discussion: Organic molecules are larger and have more variation in their features than many of the simple inorganic substances we have discussed so far. Chemists use a variety of representations to draw or sketch organic molecules that more clearly communicate these features. Molecular model kits are also a valuable tool for exploring and comparing the three dimensional shape of organic molecules.

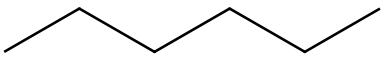
Organic molecules have a mostly carbon skeleton and any open valence on carbon is usually filled with a hydrogen atom. Because we know that we sometimes simplify our representation from the full structural formula we usually use for inorganic molecules. We may append hydrogen to the carbon label rather than right out all the carbon-hydrogen bonds, we call that a condensed formula.



Full Structural Formula



Condensed Structural Formulas



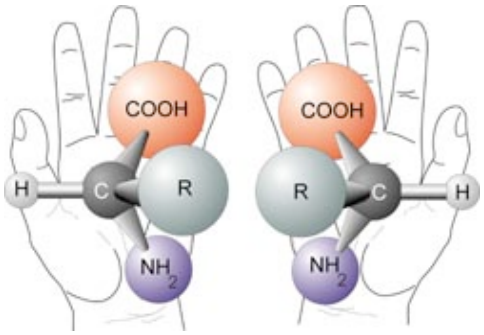
Stick (or line) Structural Formula

We may also leave out the hydrogens and carbon labels entirely and simply draw the bonds between carbon — expecting the reader to know that where any two lines meet, there is a carbon. And any open valence in carbon has a hydrogen on it. We call this a stick or line formula. All three representations have value, in representing different features of organic molecules.

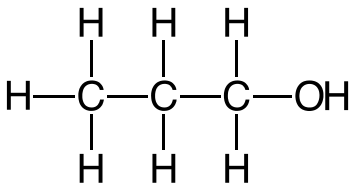
As we look at different representations of molecules, it will be important to understand how these representations are related to each other. In our experiment today we will explore three types of relationships: conformers, structural isomers, and stereo isomers.

Conformers are different representations of the same substance. Conformers have the same composition and connectivity (because it's the same molecule) — but because of a bond rotation have a different momentary shape. Like the same arm can be straight at one moment and bent the next. Understanding all the shapes, all the conformers, of a single substance helps us understand that substance.

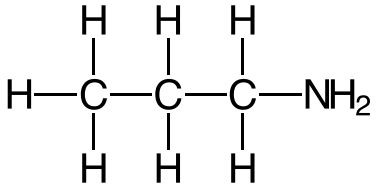
Isomers are representations of different but related substances. There are many kinds of isomeric relationships. **Structural isomers** are molecules that have the same composition — the same number of each type of atom — but have different connectivity. **Stereo isomers** are substances related at a more subtle level. Stereo isomers have the same composition, the same connectivity, sometimes even the same shape. But are not superimposable on each other. As an example, your left hand has the same bones connected the same way as your right hand — but there is a subtle difference. You cannot put your right hand into the same glove that fits your left hand.



Functional Groups will also be explored. The properties of substances can be changed dramatically by the addition of a small group of atoms that add new functionality to the molecule. Like a bronze spearhead or small hook can entirely change the function of a long stick. Recognizing these important functional groups and identifying the family of compounds that share the properties it brings to a molecule is a valuable skill. For example, adding a an oxygen with a hydrogen attached to it (—OH is a hydroxy group) to a molecule dramatically raises it's boiling point and water solubility. We call this family of substances alcohols.



Ethanol (an alcohol)



Ethylamine (an amine)

If we add a nitrogen instead of an oxygen though, the boiling point is much less and the otherwise identical substance often has a smell similar to dead fish. The $—NH_2$ group is an amino group and the family of compounds it defines are called amines.

Exp # _____

Name: _____

Student ID: _____

Chem 10 — *Intro Chem*
De Anza College

Class Section: _____

Experiment Title: _____

Unk#: _____ Bench / Locker : _____/_____

(write N/A if no unknown for this experiment)

This box is for use by your instructor.

_____	_____	_____
pre-lab	report	total

Unknown Composition or Identity:

A report must be submitted for all lab experiments conducted to receive credit for your participation. You may only report on experiments you conducted.

Reminder: All experiment reports should include each of the following sections. Each section should start on a new page and be clearly labeled.

- Cover Page (this page)
- 1. Pre-Lab
  - Describe the objectives of this experiment (what you hope to conclude).
  - Any pre-lab questions must be considered and answered before the start of the lab period. Your instructor will initial those pages and they must be included in your lab report to receive full credit for them.
  - If there is a pre-lab quiz it will be graded and returned to you during that lab period. It should be attached to your report to ensure you receive full credit.
- 2. Data
  - Empirical data, only what you observed and others could if they repeated your experiment. Observations both qualitative and quantitative (measurements).
- 3. Analysis (calculations)
  - Provide demonstrations (justification) of how your conclusions were developed from your observations. Most often accomplished with dimensional analysis or algebra (calculations). For some experiments other methods will be demonstrated and need to be applied.
  - It is only "known" if it can be justified … otherwise it's a guess.
- 4. Conclusions
  - Your final answers. What you came to know by doing this experiment. Be clear and brief, conclusions should not be more than one page and are often only a few sentences.
  - If other factors effected your final answer, briefly describe them on this page and suggest how they may have effected your experiment.
- 5. Questions
  - Attach and answer any post lab questions.

DATA

Part A — Representing Organic Molecules

(1) C_2H_6
(2) C_3H_4
(3) $CH_3CH(CH_3)_2$
(4) C_6H_6 (ring system)
(5) C_2H_5OH
(6) $CH_3OC_2H_5$

Part B — Structural Isomer and Conformer Relationships

Model B1 — A four atom chain hydrocarbon with no unsaturations. The most linear arrangement of carbon atoms (will form a zig zag pattern).

Model B2 — Using model B1, hold two atoms stationary and rotate around the next C—C bond 180˚

Model B3 — Start with model B1.

- Disconnect the fourth carbon, keep that carbons attached hydrogens.
- Disconnect the bond between the second carbon atom and one of it's hydrogens.
- Connect the fourth carbon to the valence that is now open on the second carbon.
- Fill in any remaining open valence with hydrogen.

Part C — Structural Isomer and Stereo Isomer Relationships

Model C1 — Connect two carbon atoms with a double bond. To one carbon atom, connect a chlorine atom and also a hydrogen atom. To the other carbon atom, also connect one chlorine atom and one hydrogen atom.

Model C2 — Duplicate Model C1. On only one carbon atom, switch the position of the hydrogen and chlorine atoms.

Model C3 — To a single carbon atom connect a hydrogen atom, a chlorine atom, a bromine atom and an iodine atom. Use different colored balls from the model set to represent the different elements attached to carbon.

Model C4 — Duplicate Model C3. Disconnect and reattach a hydrogen and chlorine atom to switch their positions.

Model C5 — To a single carbon atom connect two hydrogen atoms, a chlorine atom, and a bromine atom. Use different colored balls from the model set to represent the different elements attached to carbon.

Model C6 — Duplicate Model C5. Disconnect and reattach a hydrogen and chlorine atom to switch their positions.

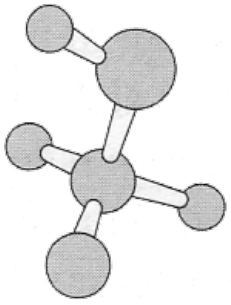
Part D — Functional Groups — Formula to Model

Model D1 — Build a model of $CH_3CH_2CH_2OH$

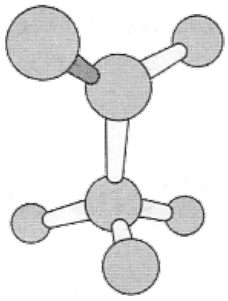
Model D2 — Build a model of $CH_3CH_2OCH_3$

Part E — Functional Groups — Model to Formula

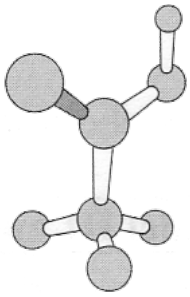
In each of the models shown below a single bond is white and a double (or aromatic) bond is colored. All atoms are either carbon (which has four bonds), nitrogen (which forms three bonds), oxygen (two bonds) or hydrogen (one bond).



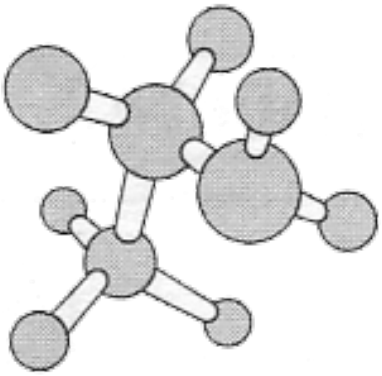
Model E1



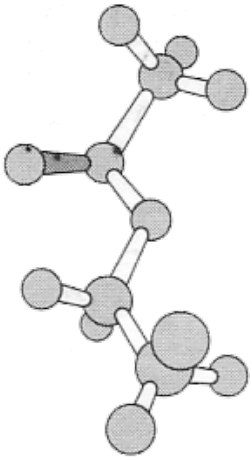
Model E2



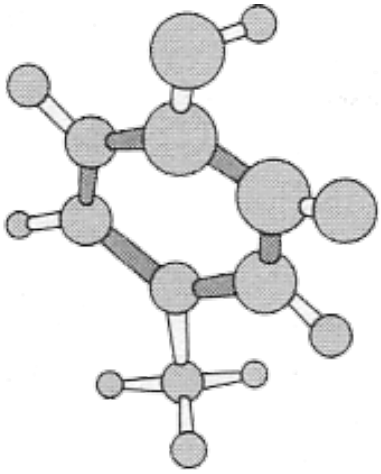
Model E3



Model E4



Model E5



Model E6

ANALYSIS

Part A — Representing Organic Molecules

	Condensed Formula	Full Formula	Stick Formula
A1			
A2			
A3			
A4			
A5			
A6			

Part B — Structural Isomer and Conformer Relationships

B1	B2	B3

Compare B1 and B2:

Y or N

1. Build the models B1 and B2.
2. Draw a stick structure to represent models B1 and B2 in the table above.
3. Do the models have the same molecular formula (the same composition)? 3. _____
4. Are the atoms in these in these models connected in the same order (the same connectivity)? 4. _____
5. Do the models have the same 3-dimensional arrangement (shape)? 5. _____
6. Can one model be converted to the other by rotating it's bonds? 6. _____

Decide if the models B1 and B2 are conformers of the same substance or if they are structural isomers (different substances).

In your conclusion, report this determination and explain why.

Compare B2 and B3:

1. Keep model B2 and build the model B3.
2. Draw a stick structure to represent model B3 in the table above.

3. _____

4. _____

Answer questions 3-6 comparing models B2 and B3.

Decide if the models B2 and B3 are conformers of the same substance or if they are structural isomers (different substances).

5. _____

6. _____

In your conclusion, report this determination and explain why.

Part C — Structural Isomer and Stereo Isomer Relationships

C1	C2

Compare Structures C1 and C2:

1. Build the models C1 and C2.
2. Draw the full structure of C1 and C2 in the table above.
3. Do the models have the same molecular formula (the same composition)?
4. Are the atoms in these in these models connected in the same order (the same connectivity)?
5. Do the models have the same 3-dimensional arrangement (shape)?
6. Can one model be converted to the other by rotating it's bonds?

Decide if the two models represent the same substance or different substances.

If the two structures represent different substances decide if two are either structural isomers or stereo isomers.

In your conclusion, report this determination and explain why.

Compare Structures C3 and C4:

Repeat steps 1 and 3-6 for C3 & C4.

Compare Structures C5 and C6:

Repeat steps 1 and 3-6 for C5 & C6.

C1 & C2
Y or N

3. _____
4. _____
5. _____
6. _____

C3 & C4
Y or N

3. _____
4. _____
5. _____
6. _____

C5 & C6
Y or N

3. _____
4. _____
5. _____
6. _____

Part D — Functional Groups — Formula to Model

D1	D2

Compare Structures D1 and D2:

D1 & D2
Y or N

1. Build the models D1 and D2.
2. Draw the stick structure of D1 and D2 in the table above.
3. Do the models have the same molecular formula (the same composition)? 3. _____
4. Are the atoms in these in these models connected in the same order (the same connectivity)? 4. _____
5. Can one model be converted to the other by rotating it's bonds? 5. _____

What is the relationship between the two models?

In your conclusion, report this determination and explain why. Also, report on what functional group identifies D1 and D2.

Part E — Functional Groups — Model to Formula

Determine the Identity

For each of the models shown in section E determine what substance is being represented. Show that substance in the following table by writing it's condensed and stick formulas. Identify the functional group (group of atoms that indicate it's family) and the family of compounds it belongs to. Include this information in the table below.

To make your determination consider the valence of each atom shown in the model. Assume any atom that forms four bonds is carbon, with three is nitrogen, with two oxygen, and with one hydrogen. Remember that double bond will count as two bonds for satisfying the atoms valence.

	Condensed Formula	Stick Formula	
E1			Functional Group: Family:
E2			Functional Group: Family:
E3			Functional Group: Family:
E4			Functional Group: Family:
E5			Functional Group: Family:
E6			Functional Group: Family:

QUESTIONS

Post-Lab Questions:

1) Based on the work you did in Part B, what feature can be used to distinguish between structural isomers and conformers?

2) Draw three structural isomers for each formula below.

   1) C_5H_{12}

   2) $C_4H_{10}O$

   3) C_5H_{10}

3) Based on the work you did in Part C, what question should you ask yourself to distinguish between structural isomers and stereoisomers?

4) Models D1 and D2 represent two structural isomers having the chemical formula C_3H_8O. What is a third structural isomer of that formula? Draw the full structure below and name it's the functional group.

Periodic Table

	1A[a] 1	2A 2	3B 3	4B 4	5B 5	6B 6	7B 7	8B 8	8B 9	8B 10	1B 11	2B 12	3A 13	4A 14	5A 15	6A 16	7A 17	8A 18
1	1 H 1.008																	2 He 4.003
2	3 Li 6.94	4 Be 9.012											5 B 10.81	6 C 12.01	7 N 14.01	8 O 16.00	9 F 19.00	10 Ne 20.18
3	11 Na 22.99	12 Mg 24.31											13 Al 26.98	14 Si 28.09	15 P 30.97	16 S 32.06	17 Cl 35.45	18 Ar 39.95
4	19 K 39.10	20 Ca 40.08	21 Sc 44.96	22 Ti 47.87	23 V 50.94	24 Cr 52.00	25 Mn 54.94	26 Fe 55.85	27 Co 58.93	28 Ni 58.69	29 Cu 63.55	30 Zn 65.38	31 Ga 69.72	32 Ge 72.63	33 As 74.92	34 Se 78.96	35 Br 79.90	36 Kr 83.80
5	37 Rb 85.47	38 Sr 87.62	39 Y 88.91	40 Zr 91.22	41 Nb 92.91	42 Mo 95.96	43 Tc [98]	44 Ru 101.07	45 Rh 102.91	46 Pd 106.42	47 Ag 107.87	48 Cd 112.41	49 In 114.82	50 Sn 118.71	51 Sb 121.76	52 Te 127.60	53 I 126.90	54 Xe 131.29
6	55 Cs 132.91	56 Ba 137.33	57 La 138.91	72 Hf 178.49	73 Ta 180.95	74 W 183.84	75 Re 186.21	76 Os 190.23	77 Ir 192.22	78 Pt 195.08	79 Au 196.97	80 Hg 200.59	81 Tl 204.38	82 Pb 207.2	83 Bi 208.98	84 Po [208.98]	85 At [209.99]	86 Rn [222.02]
7	87 Fr [223.02]	88 Ra [226.03]	89 Ac [227.03]	104 Rf [261.11]	105 Db [262.11]	106 Sg [266.12]	107 Bh [264.12]	108 Hs [269.13]	109 Mt [268.14]	110 Ds [271]	111 Rg [272]	112 Cn [285]	113	114 Fl [289]	115	116 Lv [292]	117*	118

	58 Ce 140.12	59 Pr 140.91	60 Nd 144.24	61 Pm [145]	62 Sm 150.36	63 Eu 151.96	64 Gd 157.25	65 Tb 158.93	66 Dy 162.50	67 Ho 164.93	68 Er 167.26	69 Tm 168.93	70 Yb 173.05	71 Lu 174.97
	90 Th 232.04	91 Pa 231.04	92 U 238.03	93 Np [237.05]	94 Pu [244.06]	95 Am [243.06]	96 Cm [247.07]	97 Bk [247.07]	98 Cf [251.08]	99 Es [252.08]	100 Fm [257.10]	101 Md [258.10]	102 No [259.10]	103 Lr [262.11]