Chemistry 104, Dr. Batterton
Help Sheet #3 – Chapter 10 (Part I)
Tony Jacob

CHAPTER 10 (Part I): *Drawing/Naming Organic Molecules, Functional Groups, Isomers*

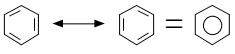
DRAWING: Organic Molecules: H, F, Cl, Br, I - 1 bond; O - usually 2 bonds; N - usually 3 bonds; C - 4 bonds

NAMING

Hydrocarbons - molecules comprised of hydrogen and carbon

1. Find longest C chain
2. Number the longest C chain to give smallest numbers for functional group or branches
3. Prefixes (#carbon atoms): Meth (1), Eth (2), Prop (3), But (4), Pent (5), Hex (6), Hept (7), Oct (8), Non (9), Dec (10)
4. Suffixes: "ane" for alkanes, "ene" for alkenes, etc.; see below for other suffixes
5. a. Branches: add "yl" to prefix; e.g., 1-C branch = meth+yl = methyl; 2-C branch = eth+yl =ethyl; etc.
   b. Duplicate branches: di (2), tri (3), tetra (4) as in two 2-C branches = diethyl
   c. Alphabetize multiple branches; do not alphabetize on the di, tri, or tetra
      ethyl before propyl; ethyl before dimethyl (alphabetize on the "e" and "m," ignore the "di")
   d. **Every branch** must have a **number** (carbon position) associated with it; every number has a branch
   e. Commas between numbers; dashes ("-") between numbers and letters
6. Alkene functional group: check for cis/trans isomers

FUNCTIONAL GROUPS (the first 5 out of 13)

Functional Group	Suffix	Formula	Other Info
Alkane	ane	C–C	saturated; tetrahedral; sp^3; C_nH_{2n+2}
Alkene	ene	C=C	unsaturated; trigonal planar; sp^2; C_nH_{2n}; geometric isomers (cis/trans)
Alkyne	yne	C≡C	unsaturated; linear; sp; C_nH_{2n-2}
Cyclic	cyclo + (ane, ene, or yne)		unsaturated; strained tetrahedral; sp^3; C_nH_{2n}
Aromatic	benzene	C_6H_6 	planar molecule; trigonal planar geometry at each C; sp^2; 120°

Alkanes: only carbon-carbon single bonds; 1 sigma (σ) bond between C atoms; **saturated** molecules; formula C_nH_{2n+2}; (R); carbon-carbon single bond **can rotate**

Alkenes: at least one carbon-carbon double bond = σ + π bonds; formula C_nH_{2n}; (R=R'); C-C double bond **can't rotate because of π bond;** has *geometric* isomers: cis and trans; **unsaturated** molecule

Alkynes: at least one carbon-carbon triple bond = σ + 2π bonds; formula C_nH_{2n-2}; (R≡R'); C–C triple bond **can't rotate because of π bond; unsaturated** molecule

Cyclic: ring compounds; formula C_nH_{2n}; 3-membered ring unstable; 4-membered ring somewhat stable; 5-membered ring stable and almost planar; 6-membered ring very stable puckered

Aromatic: has a benzene or benzene derivative; all C—C bonds equivalent in benzene ring; BO = 1.5; planar molecule; Naming: "omp" - "ortho" (1,2-disubstituted), "meta" (1,3-disubstituted), "para" (1,4-disubstituted)

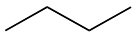
Hydrocarbons – only hydrogen and carbon: colorless, nonpolar

Properties $C_1 – C_4 \rightarrow$ *gases*; $C_5 – C_{17} \rightarrow$ *liquids*; C_{18} – higher → *solids*

Nonpolar; immiscible in water; found as a wide range of chain lengths (fossil fuels); made smaller by *cracking*; branches added (structure changed) by *reforming* – more branches allows for better combustion; octane rating refers to how much isooctane (2,2,4-trimethylpentane) is present

ISOMERS

Structural Isomers: Same formula, different connectivity (bonding). For example, the different structures for

C_4H_{10} (butane  and 2-methylpropane )

Stereoisomers: A change in the spatial arrangement of atoms; <u>bonding unchanged</u>.

I. Optical Isomers

Chiral (pronounced ki-ral) molecules are molecules with a chiral center, usually C. **To be a chiral center, the C must have 4 different groups attached to it.** If it does, the molecule will

- be chiral
- have a non-superimposible mirror image
- the two mirror images are called enantiomer (pronounced e-nan-tee-oh-mer) pairs
- be optically active because it will rotate plane-polarized light
- optical isomers have the same physical properties (boiling point, D, etc.), and will only differ in rotating plane-polarized light (one clockwise, the other counterclockwise) and in their chemical reactivity

II. Geometric Isomers: *Cis* versus *Trans* configuration

Does this molecule have geometric isomers?

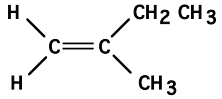
1. MUST contain a C=C
2. On <u>each</u> carbon of the C=C, there must be 2 different groups.

If either step 1 or 2 is not true, then this molecule does not have *cis*/*trans* isomers.

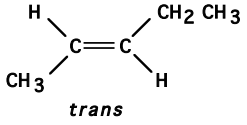
If molecule has geometric isomers, is it *cis* or *trans*?

1. For <u>each</u> carbon of the carbon-carbon double bond, circle the larger group.
2. Draw a line through the carbon-carbon double bond.
3. If the two circled groups are on the same side of the line: *cis*. On different sides: *trans*.

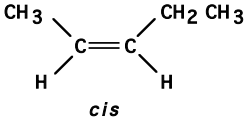
This molecule does **not** have *cis* or *trans* isomers. On the left carbon of the carbon-carbon double bond, there are 2 H (must have different groups on each carbon of the carbon-carbon double bond.)



This molecule has *cis* and *trans* isomers. Each carbon of the carbon-carbon double bond has different groups attached. (Note: there doesn't have to be 4 different groups, just 2 different groups on each C of the double bond).



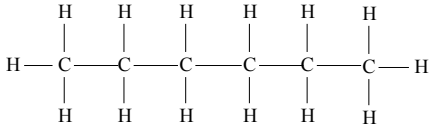
trans

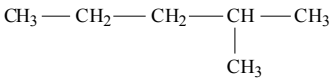


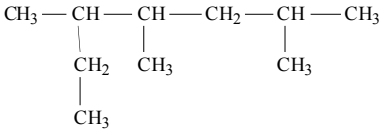
cis

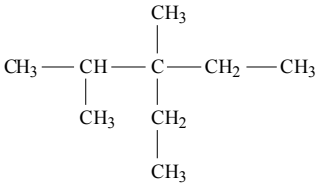
1. Draw the following molecules in the expanded format, condensed format, and line format (stick).
a. $CH_3CH_2CH_2CH_2CH_2CH_3$ b. $(CH_3)_2CC(CH_3)_2$ c. $CHCCH_3$

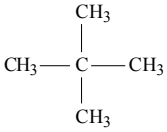
2. Give the proper name for each of the following molecules.

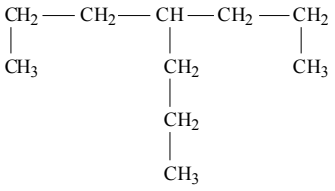
a. 

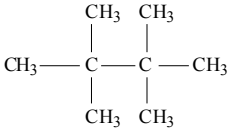
b. 

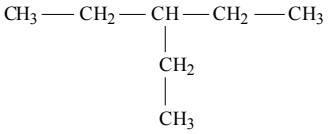
c. 

d. 

e. 

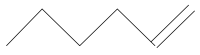
f. 

g. 

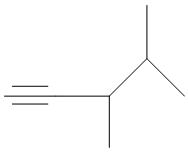
h. 

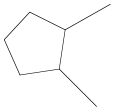
3. Write the condensed structures for the organic molecules from the names given.
a. 2,2,4-trimethylpentane b. 1,1,2-trichlorohexane c. 3,4,5-triethyl-2, 6-dimethyloctane
d. 1,1,2-trichlorocyclopentane

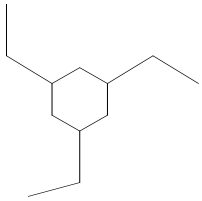
4. Give the proper name for each of the following molecules.

a. 

b. 

c. 

d. 

e. 

5. A compound has a molecular formula $C_{35}H_{70}$. What functional group could this molecule contain?
a. alkane b. alkene c. alkyne d. alcohol e. Insufficient information to make such a determination.

6. Draw the two resonance structures using stick notation that are used to represent benzene, C_6H_6.

7. Write the condensed structures for the organic molecules from the names given.
a. 2, 3-dichloro-*trans*-2-hexene b. 4, 4-dibromo-2, 3-dimethyl-*cis*-2-pentene

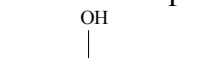
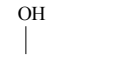
8. Draw and name all 3 structural isomers for C_5H_{12}. Use stick notation.

9. Draw and name all 8 structural isomers for $C_5H_{11}Cl$. Use stick notation.

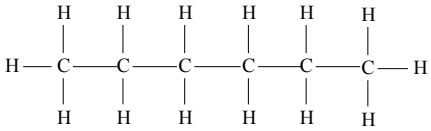
10. Draw and name all 5 structural isomers for C_3H_6ClBr. Use stick notation.

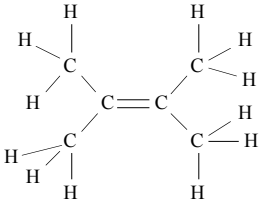
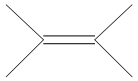
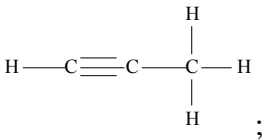
11. Draw and name all 6 possible *structural and geometric* alkene isomers (*cis*/*trans*) with the formula C_5H_{10}; do not include cycloalkanes.

12. Identify which of the following molecules have optical isomers.

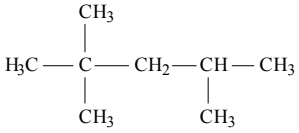
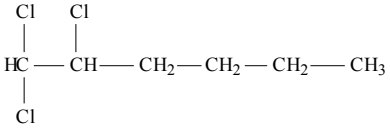
a. CHClBrI b. $CH_3CH_2CH_3$ c.  d. $CH_3CH_2CHClCH_3$ e. 

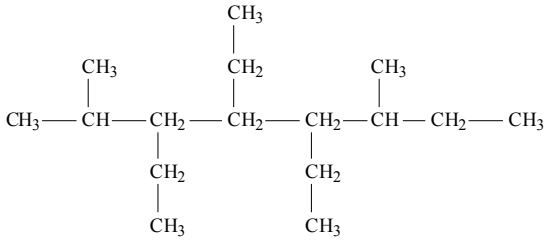
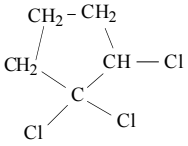
ANSWERS

1. a.  ; $CH_3CH_2CH_2CH_2CH_2CH_3$; 

b.  ; $(CH_3)_2C=C(CH_3)_2$;  c.  ; $CH\equiv CCH_3$; 

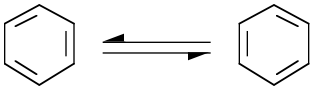
2. a. hexane b. 2-methylpentane c. 2, 4, 5-trimethylheptane d. 3-ethyl-2, 3-dimethylpentane e. 2, 2-dimethylpropane f. 4-propylheptane g. 2, 2, 3, 3-tetramethylbutane h. 3-ethylpentane

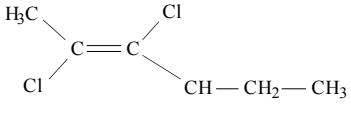
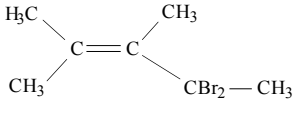
3. a.  b. 

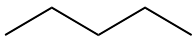
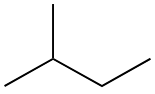
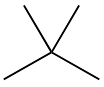
c.  d. 

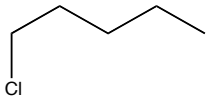
4. a. 1-hexene b. 1-butyne c. 3,4-dimethyl-1-pentyne d. 1,2-dimethylcyclopentane e. 1,3,5-triethylcyclohexane

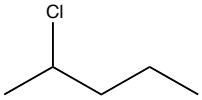
5. b

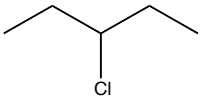
6. 

7. a.  b. 

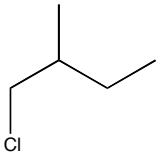
8.  pentane;  2-methylbutane;  2,2-dimethylpropane

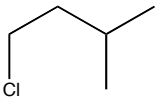
9. 

1-chloropentane; 

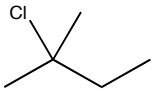
2-chloropentane; 

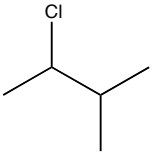
3-chloropentane ;



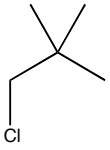
1-chloro-2-methylbutane; 

1-chloro-3-methylbutane;

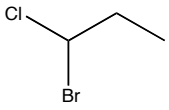


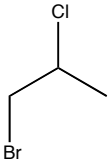
2-chloro-2-methylbutane; 

2-chloro-3-methylbutane;

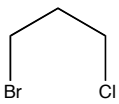


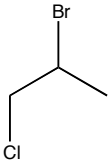
1-chloro-2,2-dimethylpropane

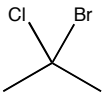


10. 1-bromo-1-chloropropane; 

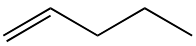
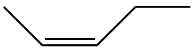
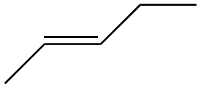
1-bromo-2-chloropropane;



1-bromo-3-chloropropane; 

2-bromo-1-chloropropane; 

2-bromo-2-chloropropane

11. 
1-pentene; 
cis-2-pentene; 
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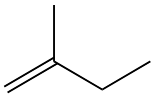
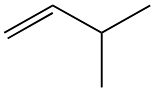
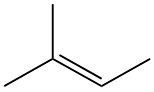

2-methyl-1-butene; 
3-methyl-1-butene; 
2-methyl-2-butene

12. a, d, and e have optical isomers