Naming Organic Molecules

Besides understanding the ester formation reaction, the naming of organic molecules is another important lesson. Naming organic molecules is actually rather involved. We are just going to touch on the basics. In short, it's all about prefixes and fancy endings.

The prefixes tell you how many carbons there are. The most common prefixes are in the table below.

ORGANIC PREFIXES	= # of Carbons
Meth-	one
Eth-	two
Prop-	three
But-	four
Pent-	five
Hex -	six
Hept-	seven
Oct -	eight
Non-	nine
Dec-	ten

The endings tell you the type of organic chemical.
We are just going to focus on 11 of the many types.

1. **Alkanes**- Hydrocarbons (containing only C & H) that contain ONLY single bonds.
-Name of alkanes always end in -ane.

Ex: prefix + ane

- Just a certain # of carbons (as specified by prefix) with H's making all of the carbons "happy"! Remember, there can only be single bonds and carbon can only make four total bonds per carbon.

EX: *Propane*

1. "Prop-" means THREE CARBONS. Draw out your carbon chain...

C -- C – C

2. Knowing that carbon always wants to make FOUR bonds, make all of the carbons "happy" by filling in H's.

```
    H   H   H
    |   |   |
H–C – C – C–H    =    C3H8   or   CH3CH2CH3
    |   |   |
    H   H   H
```

3. Write the formula from your drawing.

- If you don't like drawing your alkanes out, their formula is represented by the following equation:

C_nH_{2n+2}

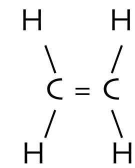
- EX: methane CH_4, ethane C_2H_6, propane C_3H_8

2. **Alkenes**- Hydrocarbons that contains at least one double bond
- Name of alkene always ends in -ene.

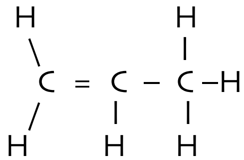
Ex: prefix + ene

- A certain # of carbons (as specified by prefix) with one double bond. The double bond could be between any two carbons in the molecule, but for our purposes - always put the double bond between the first two carbons.
- You can draw the structure out or just know that the formula for an alkene is represented by → C_nH_{2n}

- EX: ethene or ethylene (same thing) = C_2H_4



-propene or propylene (same thing) = C_3H_6



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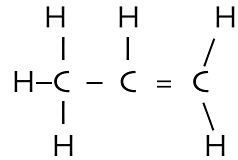


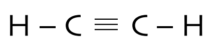
3. **<u>Alkynes</u>**- Hydrocarbons that contains at least one triple bond
   - Name of alkynes always end in -yne.

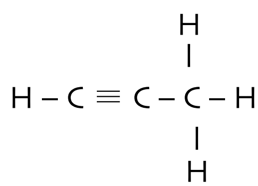
Ex: prefix + yne

- A certain # of carbons (as specified by prefix) with one triple bond. The triple bond could be between any two carbons in the chemical, but for our purposes, always put the triple bond between the first two carbons.
- You can draw the structure out or just know that formula is represented by:

$$C_nH_{2n-2}$$

EX: ethyne = C_2H_2





← propyne = C_3H_4

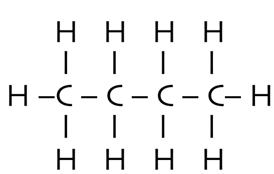
FUNCTIONAL GROUPS:

* 4. **<u>Alcohols</u>**- Organic compounds in which a hydrogen has been replaced with an -OH group.
   - General format: R -- OH, where R is a carbon chain.
   - Name of alcohols always ends in -anol.

Ex: prefix + anol

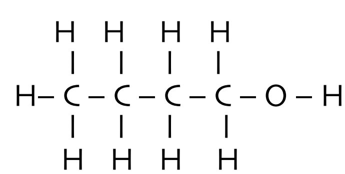
- To get the formulas, it is often very helpful to draw out the structure.

EX: *Butanol* 1. "But-" means the alcohol comes from "butane" and has FOUR carbons.



"butane"

2. replace an "H" w/ OH group



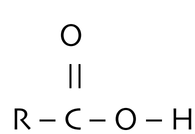
"butanol"

3. Write the formula from the picture. Butanol = C_4H_9OH or $CH_3CH_2CH_2CH_2OH$

- EX: methanol = CH_3OH, ethanol = C_2H_5OH, propanol = C_3H_5OH

* 5. **<u>Organic Acids or Carboxylic acids</u>**
   - Organic compounds that contains a carboxyl group....COOH.

- General format R-COOH



The "H" from the carboxyl group is actually acidic (meaning it can dissociate in water to make H+). However, all organic acids are WEAK acids. Names of organic acids always end in -anoic acid.

EX: prefix + anoic acid

However, many organic acids are more often named via common names that don't follow this convention! Doh! To get the formulas, it is often helpful to draw out the structure

EX: *Ethanoic Acid* 1. "Eth" means TWO carbons. C – C

```
                          O
                          ||
2. One of the C's will have a carbonyl group.    C – C – O – H
```

```
                                                   H   O
                                                   |   ||
3. Make all of the remaining C's happy with H's.  H – C – C – O – H
                                                   |
                                                   H
```

4. Write the formula. Ethanoic Acid (or ACETIC ACID) = CH_3COOH
** Please notice that the common name for <u>ethanoic acid is acetic acid</u>!!!

- EX: methanoic acid (formic acid) = HCOOH, butanoic acid (butyric acid) = C_3H_7COOH

```
     O                     □          H   H   H   O          □
     ||                               |   |   |   ||
H – C – O – H                     H – C – C – C – C – O – H
                                      |   |   |
                                      H   H   H
```

6. **<u>Esters</u>**: - For us, an ester is made when an alcohol and carboxylic acid react. You will see this in the introduction of the Ester's Lab.

```
                                           O
                                           ||
The general format of an ester is.....R – C – O – R'
                                      ↗       ↖
                          {from acid}           {from alcohol}
```

- Name esters by considering the acid and the alcohol that reacted to make the ester in question. Name the alcohol first - then the acid. For the alcohol, change the ending to -yl and for the acid, change the ending from "ic" to "ate." This naming convention can be used on the systemic name or common name that is given to you for the acid or alcohol.

EX: <u>(alcohol)</u>-yl <u>(acid)</u>-ate

EX: propanol + ethanoic acid = $\overset{\text{prefix}}{\text{propyl}}$ $\overset{\text{prefix}}{\text{ethanoate}}$ (remember the common name for ethanoic acid is acetic acid)

So it can also be . . . propanol + acetic acid = propyl acetate

EX: methanol + butanoic acid = $\overset{\text{prefix}}{\text{methyl}}$ $\overset{\text{prefi}}{\text{butanoate}}$ (remember the common name for butanoic acid is butyric acid)

So it can also be . . . methanol + butyric acid = methyl butyrate

The remaining functional groups are important to recognize but not so important to name....

7. **Aldehydes**: - An aldehyde contains a C=O (carbonyl group) connected to at least 1 hydrogen atom. $R-\overset{\overset{O}{||}}{C}-H$

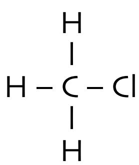
8. **Ketones** - A ketone is similar to an aldehyde in that it also contains a C=O (carbonyl group), but in a ketone the carbon in the carbonyl group is not connected to any hydrogen atoms. $R-\overset{\overset{O}{||}}{C}-R'$

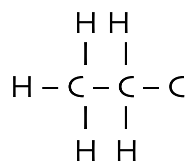
9. **Ethers** - In an ether, an oxygen atom serves as a link in a hydrocarbon chain. $R-O-R'$

10. **Amines** - In an amine, a hydrogen atom has been replaced by an amino group (NH_2). $R-NH_2$

11. **Halides** - Halides are organic compounds in which one of more hydrogen have been replaced with a halide (X = F, Cl, Br, or I) $R-X$

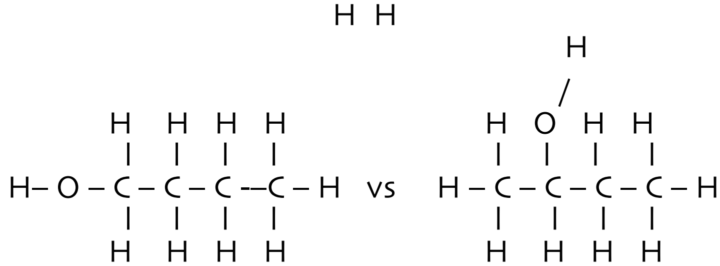
Ex: CH_3Cl = chloromethane, CH_3CH_2Cl = chloroethane





NUMBERING COMPOUNDS

Ex : Consider the following two compounds,



Both compounds would be called butanol, but these compounds are different. In the first molecule, the OH is based off of the first carbon. In the second molecule, the OH is based off of the second carbon. How can we name these compounds in such a way that the location of the -OH group is somehow indicated? Follow the following steps...

1. Determine the longest possible carbon chain in the molecule. This is the <u>parent chain</u>.
2. Next, identify anything coming off the parent chain.
3. Number the carbons in the parent chain so that the thing(s) coming off the chain can have the smallest possible numbers. As an example, butanol would be numbered....

$$HO-\underset{\underset{1}{\uparrow}}{CH_2}-\underset{\underset{2}{\uparrow}}{CH_2}-\underset{\underset{3}{\uparrow}}{CH_2}-\underset{\underset{4}{\uparrow}}{CH_3}$$

. . . where the -OH is coming off the #1 carbon as opposed to numbering it like this . . . .

$$\underset{\underset{1}{\uparrow}}{CH_3}-\underset{\underset{2}{\uparrow}}{CH_2}-\underset{\underset{3}{\uparrow}}{CH_2}-\underset{\underset{4}{\uparrow}}{CH_2}-OH$$

....where the -OH is coming off of the #4 carbon.

4. The number that the extension is coming off of is incorporated into the name:

ex: $\underset{\underset{1}{\uparrow}}{CH_3}-\underset{\underset{2}{\uparrow}}{\overset{\overset{OH}{|}}{CH}}-\underset{\underset{3}{\uparrow}}{CH_2}-\underset{\underset{4}{\uparrow}}{CH_3} \rightarrow$ 2-butanol ex: $HO-CH_2-CH_2-CH_2-CH_3 \rightarrow$ 1-butanol

$$\begin{array}{l} \quad\quad\; CH_3 \\ \quad\quad\;\; | \\ CH_3 - CH - CH_2 - CH_3 \end{array}$$

ex: $CH_3 - CH - CH_2 - CH_3$ → 2-methyl butane

$$\begin{array}{l} \quad\quad\quad\quad\quad\quad CH_2CH_3 \\ \quad\quad\quad\quad\quad\quad\;\; | \\ CH_3 - CH_2 - CH - CH_2 - CH_3 \end{array}$$

ex: $CH_3 - CH_2 - CH - CH_2 - CH_3$ → 3-ethyl pentane

ex: $H - C \equiv CH - CH_2 - CH_2 - CH_2 - CH_3$ → 1-hexyne

ex: $CH_3 - C \equiv C - CH_2 - CH_2 - CH_3$ 2 - hexyne

ISOMERS: There are many times of isomers but for our case, we our only concerned with structural isomers. Structural isomers have the exact same formula, but different organization. The following three molecules are isomers:

$CH_3 - CH_2 - CH_2 - CH_2 - CH_3$ = pentane (C_5H_{12})

$$\begin{array}{l} \quad\quad\quad\quad\; CH_3 \\ \quad\quad\quad\quad\quad | \\ CH_3 - C - CH_3 \\ \quad\quad\quad\quad\quad | \\ \quad\quad\quad\quad\; CH_3 \end{array} = (C_5H_{12})$$

2,2-dimethylpropane

$$\begin{array}{l} \quad\quad\; CH_3 \\ \quad\quad\;\; | \\ CH_3 - CH - CH_2 - CH_3 \end{array}$$

$CH_3 - CH - CH_2 - CH_3$ = 2-methyl butane (C_5H_{12})

IN SUMMARY…

TYPE	FORMULA	DESCRIPTION	EXAMPLES
Alkane	C_nH_{2n+2}	- all single bonds, only C & H	CH_4 = methane, C_2H_6 = ethane
Alkene	C_nH_{2n}	- at least 1 double bond	C_2H_4 = ethene, C_3H_6 = propene
Alkyne	C_nH_{2n-2}	1- at least triple bond	C_2H_2 = ethyne, C_3H_4 = propyne
Alcohols	R – OH	- has a hydroxyl group	CH_3**OH** = methanol, C_2H_5**OH** = ethanol
Organic Acids (Carboxylic Acids)	O ‖ R – C– OH	- has a carboxyl group (-COOH)	O ‖ CH_3**C**OH, ethanoic acid
Esters	O ‖ R – C – O – R′	- an acid + an alcohol	methyl ethanoate (methyl acetate)
Aldehydes	O ‖ R – C –H	- ends in H - has an carbonyl group	O ‖ CH_3CH_2CH, propanal
Ketone	O ‖ R – C – R′	- has a carbonyl group- - has an R group on both sides	O ‖ CH_3**C**CH_3, propanone
Ether	R – O – R′	-O sandwiched btwn two R's	CH_3–**O**–CH_2CH_3, methoxyethane
Amine	R – NH_2	- has a -NH_2 group	$CH_3CH_2CH_2$–**NH_2**, propanamine
Halide	R – X	X = F, Cl, Br, or I	H | H –C– Br | H

BREAK ASSIGNMENT: ORGANIC CHEMISTRY REVIEW QUESTIONS

1. In a future lab you will synthesize aspirin from salicylic acid and acetic anhydride. This reaction does not go to completion (there are some leftover reactants mixed with the products). Do some research and describe the method that would be best used to separate your product from the excess reagents. Make sure to explain the chemistry behind this method.

2. What do the following prefixes stand for?

   a. meth- ____________________________ b. hex- ____________________________

   c. prop- ____________________________ d. but- ____________________________

3. a) Describe the differences between an aldehyde and a ketone.

   b) Describe the difference between an organic acid and a ester.

   c) Which do you think would be more soluble in water, an organic acid or an ester. Assume both molecules to have the same R groups. Explain your reasoning.

   d) Which do you think would be more soluble in water, an ether or an alcohol. Assume both molecules to have the same R groups. Explain your reasoning.

4. a) Identify the following compounds according to their functional groups. Your choices of answers are listed below.

Alkane	Alkene	Alkyne	Alcohol	Aldehyde	Organic acid
Ester	Ether	Amine	Halide	Ketone	

b) Circle the part of the compound that is the functional group

```
1.  CH3CH2CH2C≡CH ____________________
```

```
          O
          ||
2.  CH3CH2CH ____________________
```

```
3.  CH3CH2–NH2 ____________________
```

```
           O
           ||
4.  CH3CH2COH ____________________
```

```
5.  CH3CH2–O–CH3 ____________________
```

```
6.  CH3CH=CHCH3 ____________________
```

```
        CH3
        |
7.  CH3–C–OH ____________________
        |
        CH3
```

```
        CH3
        |
8.  CH3–C–CH2–CH3 ____________________
        |
        CH3
```

5. Name the following compounds:

```
a.    CH3CH2CH2CH2CH3

____________________
```

```
                OH
                |
b.    CH3CH2CHCH2CH3

____________________
```

```
               O
               ||
c.    CH3CH2–C–OH

____________________
```

```
              O
              ||
d.    CH3CH2C–O–CH2CH3

____________________
```

```
e.    CH3–C≡C–H

____________________
```

```
          CH2CH3
          |
f.    CH3CHCH2CH2CH3

____________________
```

```
      CH3     CH2CH3
        \     /
g.       C = C
        /     \
       H       H

____________________
```

```
          Cl
          |
h.    CH3CHCH2CH3

____________________
```

i. $CH_3CH_2CH_2CH_3$

j. CH_3CH_2OH

______________________________ ______________________________

k. $CH_3CH_2CH_2C(=O)\text{–}OH$

l. CH_3Br

______________________________ ______________________________

6. From the name, draw out the structure.

a. cyclohexane

b. 2,2-dimethylpentane

c. 2-octanol

d. pentanoic acid

e. dichloromethane

f. 2-butene

g. ethyne (acetylene)

h. propyl propanoate

7. Draw as many structural isomers as you can for the following compound. $CH_3\text{-}CH_2\text{-}O\text{-}CH_2\text{-}CH_3$
(Oh yes, you should also name them!)