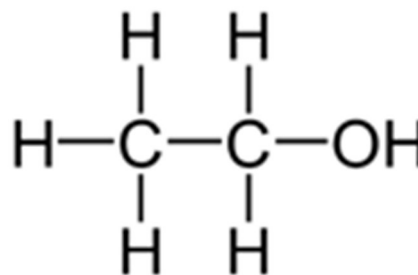
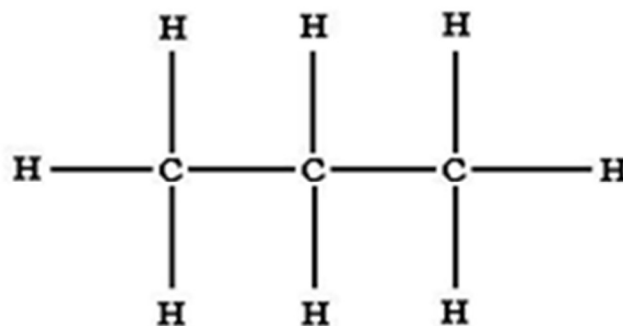
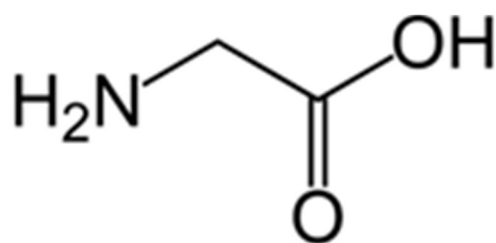
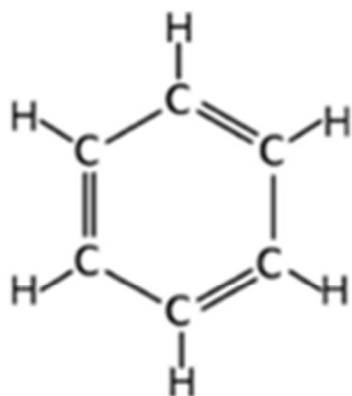
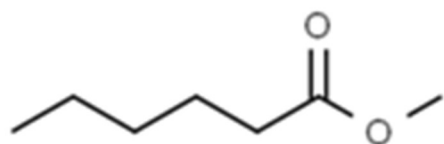

Organic Chem Class Notes



Which one is which?

Glycine is an amino acid. Ethanol is an alcohol.
Benzene will give you cancer. Propane is for combustion.
Methyl hexanoate is why bananas smell good.



1	is the first atom in all organic molecules.				
2	Carbon can make		bonds to other carbon atoms.		
3	There are no		in organic chem.		
4	Look at Table P now, write in the prefixes to “count” to ten in organic prefixes.				
	1	2	3	4	5
	6	7	8	9	10
5	Carbon must make ____ bonds because carbon has an electron configuration of				
6	Carbon atoms can make these types of bonds				
7	Hydrogen atoms have one valence electron, they can only make				
8	What is the name and formula of the simplest hydrocarbon?				
9	are the simplest molecules in organic chem, made up of only H + C atoms				
10	Table Q is called:				
11	HOMO =		LOGOS =		

12. The three “body types” or SERIES are		Example carbon bonding
ALKANES	Which have	
ALKENES	Which have	
ALKYNES	Which have	

14. Alkane Name	#C	Structural Diagram	Molecular formula and Condensed Structural Formulas
	1		
	2		
	3		
	4		
	5		

	6		
	7		
	8		
	9		
	10		

15		is the study of chemical compounds that at one time were thought to be made only by living organisms like plants or animals. This is not true, nor was it.
16		is the central atom in organic chem. Carbon makes 4 bonds always, because of its electron configuration of 2-4. It can make single, double, or triple bonds to itself.
17		are simple molecules in organic chem, made up of only of hydrogen and carbon atoms, hence this name.
18		means having the “same body type” molecules made up of only H + C. Alkenes contain ONLY ONE double bond, alkynes contain only one triple bond.

19	Alkanes... Alkane general formula is → The alkane with 4 carbons has how many hydrogen atoms? →
20	The 2 nd homologous series of hydrocarbons are the
21	The general formula for alkenes is They have less H's than alkanes because of the double C=C bond.
22	An alkene with 5 carbon atoms has the molecular formula of
23	In our class but in the real world, multiple double bonds are possible in one molecule.
24	Methene is NOT possible. The “-ene” suffix means that C=C is necessary. To have a C=C you need 2 carbon atoms. METH means:

25.	Draw ethene	Draw propene (to the “right”)	Draw propene (to the “left”)

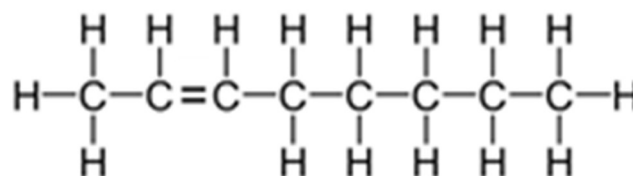
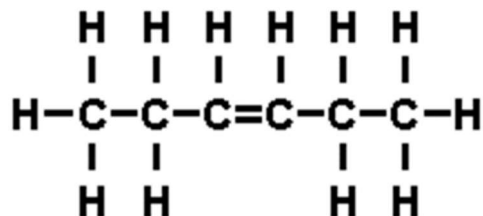
26.

Draw 2 kinds of butene now. There are 2 different ways to draw butene.
Name them, and write the condensed structural formulas (this is new) as well.

27 draw		
28	name	name
29	Condensed structural formula	Condensed structural formula
30	Isomers share a molecular formula:	

31	1-pentene	
36	2-pentene	
33	1-hexene	
34	3-hexene	

35	36	37
----	----	----



38 Name and write the condensed structural formula

39 Name and write the condensed structural formula

40. The 3rd group of hydrocarbons are the _____

In our class ALKYNES only have _____ triple bond.
 Naming and drawing will be just like the alkenes, the number tells where the triple bond is placed.

41. There is no _____ you need at least two carbon atoms to triple bond together.

42 Draw ETHYNE

43 Draw PROPYNE

44 Draw 1-butyne

45 Draw 2-butyne

46a	1-pentyne	
46b	2-pentyne	
46c	1-heptyne	
46d	3 heptyne	
47	The general formula for all ALKYNES is...	
	If an alkyne has nine carbon atoms, what is its formula?	

Objective: How to add halogens into all three kinds of hydrocarbons.

48	Table R lists
49	<p>Functional groups are added to hydrocarbons to make them _____,</p> <p>to make them more difficult, to make them _____</p> <p>and to give them a wide variety of new _____.</p> <p>The first, functional group we will add to hydrocarbons are the...</p>

	HALOGENS	symbols	Organic Chem Prefix names
50			
51			
52			
53			

54	54
55	55
56	57

The rules to naming Halocarbons:

58a.

58b.

58c.

58d.

59 Draw

Name

60 Draw

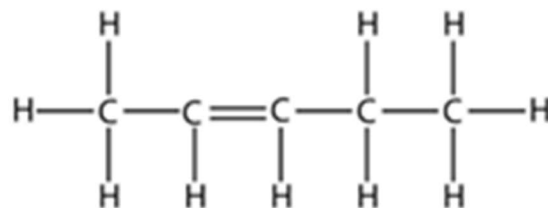
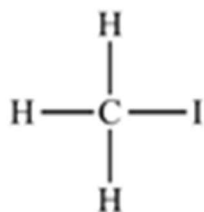
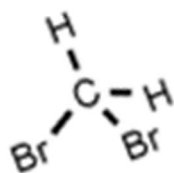
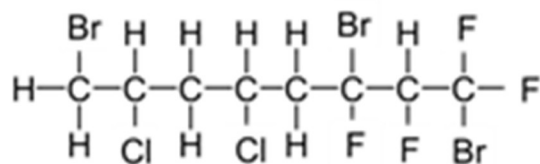
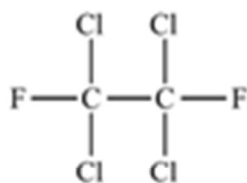
Name

60 Draw

Name

61. Draw these 1,1dibromo-2,2 difluoroethane	difluoroethyne
5bromo-4,4 dichloro-7,8,8trifluoro-1,2,3,7 tetra-iodo-1octene	

62. Name these five molecules...



63. Take out Table Q, we need to “fix” it. You write the blue text in your reference tables now...

64. Alkanes are _____ Alkanes can “hold” the most hydrogen atoms

65. Alkenes and Alkynes are both _____
 Because of their double or triple bonds, they can “hold” less hydrogen atoms than alkanes.

66. Alkanes are saturated, they can't be "_____ " to.

67. Alkanes can undergo _____ reactions only.
(alkanes CANNOT undergo addition reactions).

68. Alkenes & Alkynes are unsaturated, they undergo _____ reactions only.
(alkenes and alkynes CANNOT undergo substitution reactions).

	reactants	products
69 Names		
69 Structural diagrams		
70 Names		
70 Structural diagrams		

	Reactants structures and names	Products structures and names
71a		→
71b		→
71c		→
71d		→

72. Halogens can be substituted ONLY into _____
(the alkanes).

73. It happens _____ AT A TIME.

74. When you combine halogens with unsaturated hydrocarbons (alkenes/alkynes) a different reaction happens called an _____ reaction.

That's because when the double bond "opens up" to a single bond, and it opens 2 bonds, for BOTH halogen atoms to join the molecule, or, a triple bond opens up into a double bond, again both halogen atoms bond into the molecule.

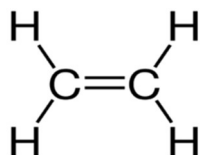
Examples of ADDITION Reactions (unsaturated hydrocarbon + halogen molecule)

75 word Ethene + Bromine form

75 drawings + Br₂ →

76 word 2-pentene + fluorine form

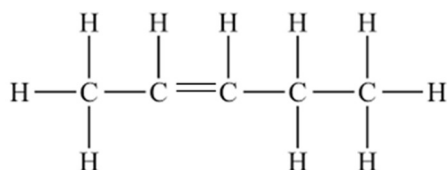
76 drawings



+ F₂ →

77 word Ethyne + chlorine form

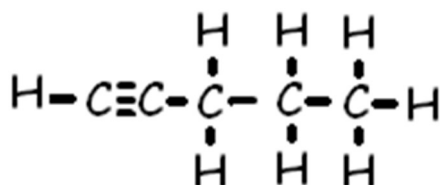
77 drawings



+ Cl₂ →

78 word 1-pentyne + iodine form

78 drawings



+ I₂ →

79. Draw the functional groups for alcohols and ethers	Functional group	General formula
Alcohols		
ethers		

“R” means the functional group bonds to a hydrocarbon here.

The R' (say R prime) means the functional group makes a bond to a different hydrocarbon here.

ALCOHOLS

80. Alcohols have an “-OH” group which is _____.

Alcohols are MOLECULAR - not ionic.

81. When the hydroxide anion is ionically bonded to a metal, that's an Arrhenius _____.

Like... (*NaOH*, or *KOH*)

82. Alcohols are _____

	How many carbons?	Structural diagram	Condensed structural formula
83 Draw methanol	1 carbon		CH₃OH
Draw ethanol	2 carbons		
84 Draw ethanol with -OH on the “right” end	2 carbons		
Draw ethanol with -OH on the “bottom left”	2 carbons		

Add names	How many carbons?	Structural diagram	Condensed structural formula
85 Draw	3 carbons		
85 Draw	3 carbons		
86. These are different ISOMERS...			

<p>87. Draw and name the three different 5-carbon alcohol molecules</p> <p>Name the base chain (count carbon atoms)</p> <p>Enumerate where the alcohol group is located.</p> <p>Alcohol names always end with the –anol suffix</p>	

C atoms names of the alcohol molecules (these are ALL the alcohol molecules in high school chem)

1	methanol
2	ethanol
3	1-propanol, 2-propanol
4	1-butanol, 2-butanol
5	1-pentanol, 2-pentanol, 3-pentanol
6	1-hexanol, 2-hexanol, 3-hexanol
7	1-heptanol, 2-heptanol, 3-heptanol, 4-heptanol
8	1-octanol, 2-octanol, 3-octanol, 4-octanol
9	1-nonanol, 2-nonanol, 3-nonanol, 4-nonanol, 5-nonanol
10	1-decanol, 2-decanol, 3-decanol, 4-decanol, 5-decanol

Naming Alcohols

COUNT the number of carbon atoms.

DETERMINE where the functional group is attached. Use this place to number that carbon in the name.

Alcohol names always end with the -anol suffix

89. Why is there not an alcohol molecule named 4-pentanol? (Draw it, you can)

ETHERS

Ether molecules are easy to recognize because they have a single atom of oxygen in the middle, and have only single bonds to the left and right

90. Ethers functional group looks like this: _____

91. and a general formula that looks like this: _____

92. Which means an R group is attached to an oxygen atom, and a different R prime group on the other side.

93	Methane	Take away one "H" atom to form...	Methyl group
94	Ethane	Take away one "H" atom to form...	
95	Propane	Take away one "H" atom to form...	

96	Butane	Take away one "H" atom to form...	butyl group
----	--------	--------------------------------------	-------------

Alkanes are SATURATED, they cannot be bonded to anything else. By removing one H atom from an alkane, you create an "ALKYL" group, with an open bond, which can attach (for example), to an oxygen atom in an ether molecule, or other types of molecules coming soon.

97	Pentane would become	Hexane would become
	Heptane would become	Octane would become
	Nonane would become	Decane would become

98.	Methyl ethyl ether	
	Propyl butyl ether	
	Pentyl methyl ether	
99.	Diethyl ether	
	Dimethyl ether	
	Hexyl ethyl ether	

100.

What's the smallest possible ether? _____

What's the biggest ether? _____

What is the 2d biggest ether? _____

Can there be double bonds, or triple bonds in *our* ethers? _____

Can there be alcohols or halogens be attached to *our* ethers? _____

Can there be two functional groups right next to each other? _____

Can there be 2 or more alcohol groups on one molecule? _____

ALDEHYDES and KETONES

101. Aldehydes + Ketones we will examine together, since they are _____ thing.

When they both have the same number of carbon atoms, they are _____.

102. Both have a _____ bond, just in different places.

103. Aldehydes always have the C=O at the end of a hydrocarbon chain.

WRITE:

104. Ketones always have the C=O in the middle of a hydrocarbon chain.

WRITE:

105. Name and draw the 3-carbon aldehyde

Name and draw the 3-carbon ketone

106. Draw these aldehydes and ketones

METHANAL HCHO

BUTANONE $\text{CH}_3\text{COCH}_2\text{CH}_3$

ETHANAL CH_3CHO

2-PENTANONE $\text{CH}_3\text{COCH}_2\text{CH}_2\text{CH}_3$

BUTANAL $\text{CH}_3\text{CH}_2\text{CH}_2\text{CHO}$

3-PENTANONE $\text{CH}_3\text{CH}_2\text{COCH}_2\text{CH}_3$

Organic Acids

107. An organic acid will release _____ in solution, just like Arrhenius acids.

108. Organic acids contain the acid functional group called the “_____” group
The R is the hydrocarbon chain that the acid group attaches to. This -COOH group always attaches at the end of the chain in our class (otherwise they get too complicated to name - wait until college!)

109. Acid functional group to the “left” side

109. Acid functional group to the “right” side

110a draw methanoic acid

110b draw ethanoic acid

110c draw propanoic acid

110d draw hexanoic acid

110e draw nonanoic acid

111. The whole list of acids in high school includes (fill in the blanks) (think too)

# carbon atoms	Name	Condensed Structural formula
1	Methanoic acid	HCOOH
2	Ethanoic acid	
3	Propanoic acid	
4	Butanoic acid	CH ₃ (CH ₂) ₂ COOH
5	Pentanoic acid	
6	Hexanoic acid	
7	Heptanoic acid	
8	Octanoic acid	CH ₃ (CH ₂) ₆ COOH
9	Nonanoic acid	
10	Decanoic acid	

112. Copy this chart... these are the same molecules with different names.

<i>Acetic Acid</i>	<i>Ethanoic Acid</i>

These molecules are identical but have different names. Acetic is “inorganic” style.

Ethanoic is “organic” style. But they are identical molecules.

Both are weak acids, both are weak electrolytes, both are vinegar, they are the same with different names.

114. Draw Propanoic acid “to the left” and “to the right”. Be sure you can see it in both directions.

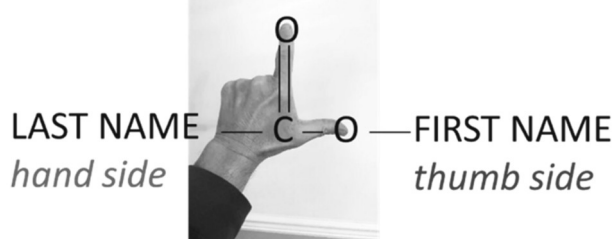
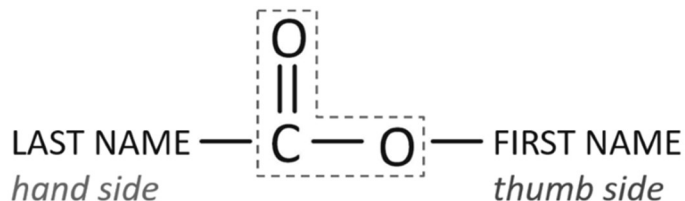
ESTERS

115. The next functional group are the ESTERS. They tend to smell _____.

They form from a reaction between an _____ + _____.

This reaction is called _____.

117. The ester functional group looks like this:



The ESTER group makes an “L” shape, like your hand.

118. The THUMB side, is the _____ side.

119. The hand side, or _____ side.

120. We ALWAYS name ESTERS the _____ first.

121. Thumb to the _____ of the functional group.

122. Thumb to the _____ of the functional group, either direction!

123. Draw Methyl Propanoate (ester) in both directions, right and left.

To the right side
Condensed structural
formula...

To the left side
Condensed structural
formula...

124. Draw
butyl propanoate

125. Draw
methyl hexanoate

125. Draw
ethyl methanoate

126. Draw ethyl propanoate

126. Draw propyl ethanoate

127. Draw propyl methanoate

Amines and Amides

Amines and Amides are similar (in the same way aldehydes + ketones were).

128. The Amines + Amides both contain _____.

129. Count to 3 for nitrogen, N must always make _____ bonds.

130. Amine groups can be on the _____ of a hydrocarbon chain

131. Amide groups are always _____ of a hydrocarbon chain.

Change the table as shown now. In our class, these are simpler with -NH_2 ends

132. Nitrogen atoms can form bonds of 3 chains...

133. In amides, the "NH₂" part bonds...

R –

134. draw methanamine

135. draw methanimide

136. draw ethanamine

137. draw ethanamide

138. draw 3-pentanamine

139. draw pentanamide (no number?)

Organic Chemical Reactions: Substitution, Addition, Fermentation, Esterification, Polymerization and Saponification

140. Propane + fluorine yields 1-fluoropropane + HF

141. Ethane + chlorine yields...

142. Butane + iodine yields 2-iodobutane + HI

143. Ethene + Bromine yields 1,2 dibromoethane

144. Propene + chlorine → 1,2-dichloropropane

145. Ethyne and fluorine → 1,2 difluoroethene

146. Fermentation is the organic chemical reaction that YEAST can turn

_____ into _____ and _____

147. Yeast excrete waste products called ethanol + CO₂

148.

149. Balance this reaction: glucose forms ethanol and carbon dioxide gas

150. Polymerization...

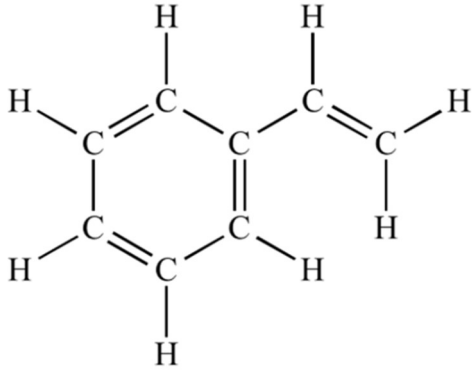
151. POLY—MER—IZATION

152. A “mer” is a molecule or unit.

153. A lot of “mers” (draw the diagrams...)

the polyethene formula is $(-\text{CH}_2\text{CH}_2-)_n$

This means that the “unit” of 2 carbons and 4 hydrogen atoms link together to form chains of

154. Other polymers that you are familiar with		“mer”
PVC, or polyvinyl chloride	Polychlorethene	
Polyethylene	Polyethene	
Styrofoam	Polystyrene	
Teflon	Tetrachloroethene	

ESTERIFICATION

is the reaction between acids and alcohols. These molecules “face” each other, functional groups close, and we take out HOH (water). The rest of the molecules then bond together making an ester with that famous COO group in the middle making an “L” shape.

155. _____

156. Combine propanoic acid + ethanol

157. butanoic acid + 1-propanol form an ester + water

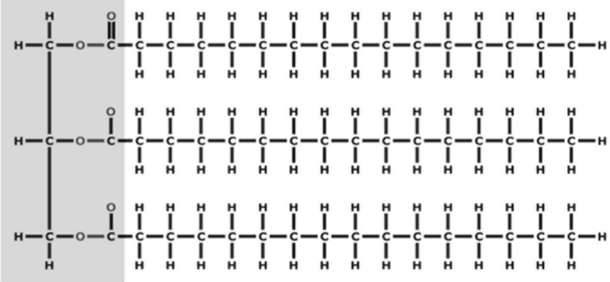
SAPONIFICATION (what if you “misspell this??)

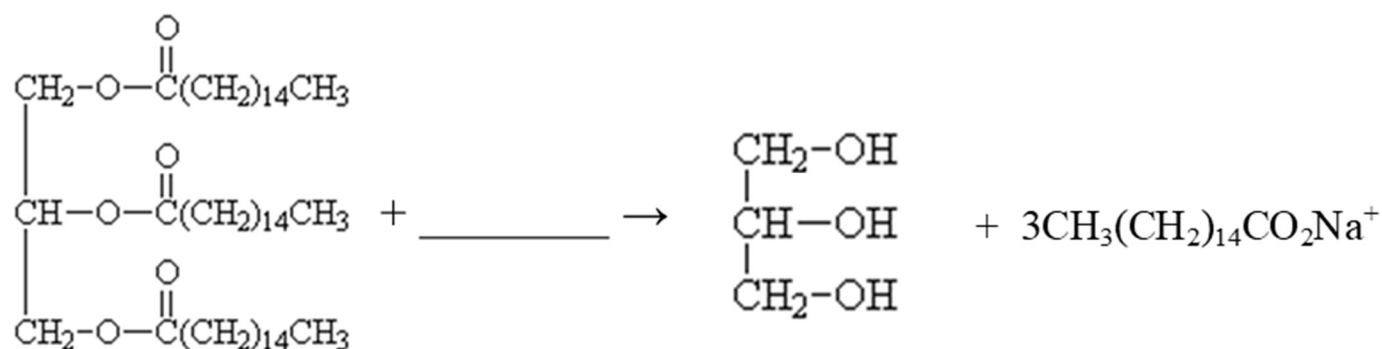
158. Saponification is the organic chemical reaction that makes _____

159. The word equation for making soap is always...

160. The reactants for saponification

161. products of saponification

<p>Triglyceride</p>  <p style="text-align: center;">+ 3 NaOH →</p>		$ \begin{array}{c} \text{H} \\ \\ \text{H} - \text{C} - \text{OH} \\ \\ \text{H} - \text{C} - \text{OH} \\ \\ \text{H} - \text{C} - \text{OH} \\ \\ \text{H} \end{array} $	$+ 3\text{CH}_3(\text{CH}_2)_{16}\text{COONa}^{+1}$
<p>Triple (3) ester or triglyceride, or FAT</p>	<p>+ 3 bases →</p>	<p>Triple (3) alcohol (glycerol)</p>	<p>3 BIG soap molecules that contain CATIONS!</p>



Circle the triple ester + three bases make circle the triple alcohol + 3 soap "molecules"

ISOMERS and Branched Hydrocarbons (first the vocabulary)

Isotopes	chemically identical atoms with different atomic masses (different # neutrons) which are the reason for average atomic masses being decimals.
Allotropes	Examples are graphite and diamonds are both pure carbon. They're bonded differently and have different properties. If you don't believe that, try to take the regents with a diamond, or get engaged with a pencil! Oxygen and ozone, O ₂ and O ₃ are also allotropes.
167. Isomers	

168. Isomer examples include ethanol and dimethyl ether.

	Structural diagrams	Condensed structural formulas
Ethanol		
Dimethyl ether		

169. Draw hexane

Draw 2methylhexane which is a pentane with a “methyl” group attached to carbon #2.

170. Draw this, name this, then draw an isomer of it.

171. Draw 4-methyl, 5-ethyl nonane

172. Draw 7ethyl, 8-fluoro, 2-nonyne

Organic Chemistry BASICS (welcome to the O.C.)

Carbon is the central atom to organic chem. Carbon has 4 valence electrons, so it can and must make 4 bonds. These bonds can be to other carbon atoms, hydrogen atoms, or any other atom or group except metal atoms or ions. The concept of hydrocarbon means that the compounds are made only of hydrogen and carbon. When other atoms, such as oxygen, nitrogen, etc., are added to the compound, they are not technically hydrocarbons anymore.

The simplest hydrocarbons are the straight chained hydrocarbons. These are the alkanes, alkenes, and alkynes. The names are all close but different. They are in Table Q.

These chains are labeled first by the number of carbons they contain. Their prefix is based up on the number of carbon atoms in the chain, in high school that is one carbon, up to ten in a row. The prefixes, from one to ten are: meth, eth, prop, but, pent, hex, hept, oct, non, dec.

Alkanes

have only C-C single bonds, and all the carbons are bonded to as many hydrogen atoms that they can be bonded to (4 bonds total per carbon). Since these hydrocarbons hold the MAXIMUM number of hydrogen atoms possible, they are called saturated hydrocarbons.

Alkanes have this GENERAL FORMULA C_nH_{2n+2} where n=the number of carbon atoms.

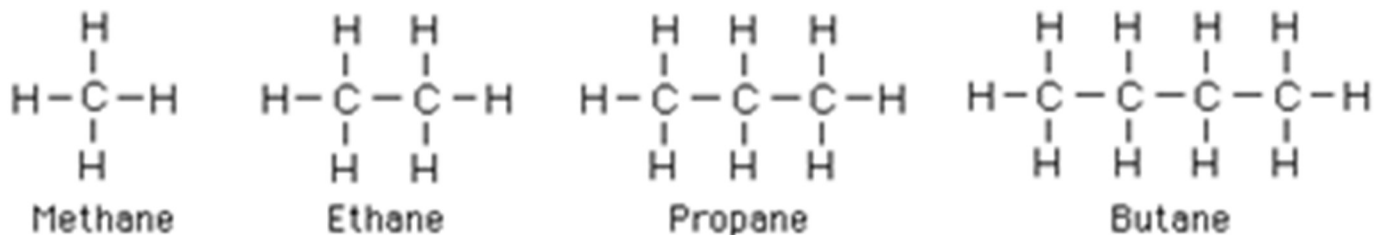
Example: an alkane with 4 carbon atoms has a chemical formula of C_4H_{10} .

Alkanes, in size order 1 to 10 are: methane, ethane, propane, butane, pentane, hexane, heptane, octane, nonane and decane.

Alkanes always end with the suffix -ane.

Alkanes are "saturated", they contain the most hydrogen atoms compared to alkenes and alkynes.

We will come back to alkanes later, when we discuss adding "special" functional groups to give these chained, saturated, hydrocarbons more properties.



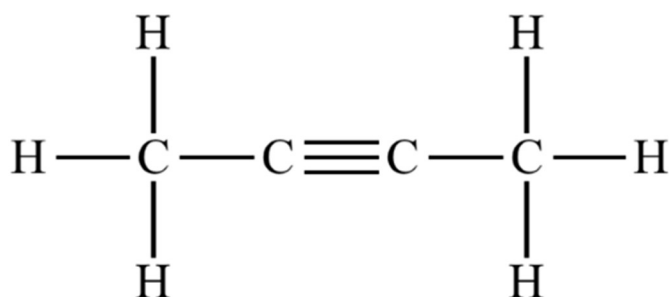
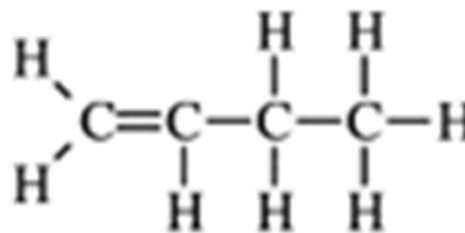
Alkenes

In high school, Alkenes have one C=C double bond. Because of their double bond, the alkenes hold two less hydrogen atoms compared to a similar sized alkane. Alkene molecules are unsaturated

Alkenes have this general formula: C_nH_{2n} where n=the number of carbon atoms. An alkene with four carbon atoms has a formula of C_4H_8

Since this double bond can be anywhere in the molecule, when we name this molecule, we need to indicate the location of this double bond. Since there are two sides to count from towards the double bond, by rule we choose the *smaller number* for the molecule name.

This molecule is 1-butene, the double bond connects carbon #1 and #2. If you called this 3-butene, you counted from the wrong side.



Alkynes

In high school, alkynes have one $\text{C}\equiv\text{C}$ triple bond. These are similar to the alkenes, but for the difference in the triple bond. We name the molecule with prefixes, and with a number to tell exactly where the triple bond is.

Alkynes are unsaturated like the alkenes. They hold less hydrogen atoms than a similar sized alkane that has only C-C single bonds.

Alkynes are always labeled with the suffix *-yne*. Alkynes have this general formula: $\text{C}_n\text{H}_{2n-2}$ where n = the number of carbon atoms.

This molecule is 2-butyne, because it has 4 total carbon atoms and the triple bond connects carbon #2 to carbon #3.

If the carbon chain is longer, we must remember to count from the “shorter end”.

FUNCTIONAL GROUPS (Table R)

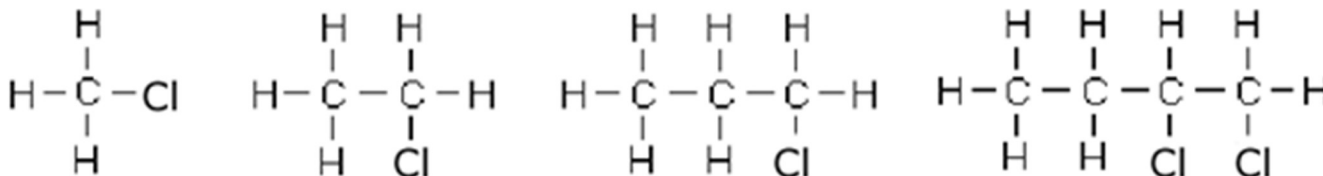
Hydrocarbons will all react in pretty much the same way, they combust, they undergo some simple reactions, but they don't have a lot of “flair”. In order to make fancier molecules we will need to add some functional groups to the hydrocarbons.

Table R shows us the groups that you are responsible to be able to recognize and name. They follow simple patterns, just like in the table. In college level organic chem the hydrocarbon chains get longer, they can form into different sized ring structures, etc. In high school this will be much easier.

HALIDES (halocarbons)

The substitution of a halogen atom (F, Cl, Br, or I) for one, or more hydrogen atoms form a halocarbon. That's a hydrocarbon with a halogen inserted where a hydrogen atom was previously bonded. Halocarbons are sometimes called halide molecules.

FOUR alkanes in a row are shown, then below them are HALOCARBONS, with chlorine atoms substituted into the molecules. They are named below.



chloromethane

chloroethane

1-chloropropane

1,2 dichlorobutane

If you used F, or Br, or I atoms, their names would change to: fluoromethane, fluoroethane, 1-fluoropropane, or 1,2 difluorobutane. (Or you might have used the bromo or iodo prefixes).

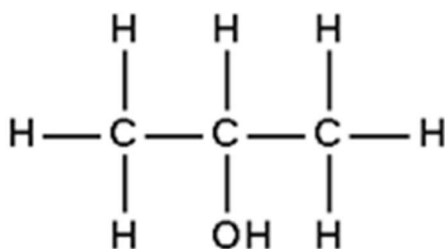
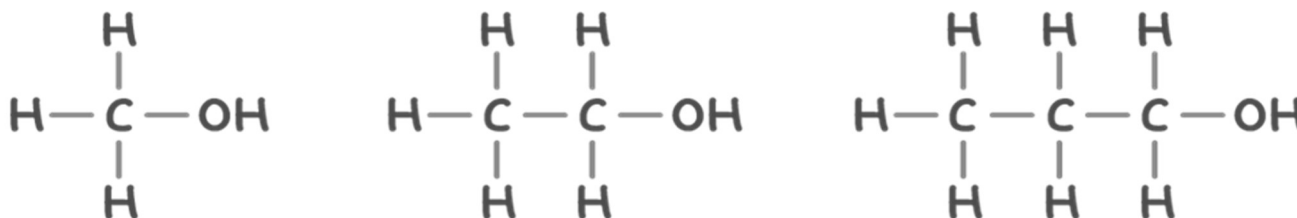
ALCOHOLS

To form an alcohol in organic chemistry we have a hydrocarbon to which an -OH group is added in. This -OH group is NOT hydroxide, it is not a base. This is an oxygen atom-hydrogen atom "group". When an -OH group is attached to a hydrocarbon, it does not dissociate in solution.

The -OH group does not form a hydroxide ion. The molecule stays whole, but it can dissolve into water as they do not have radial symmetry.

The alcohol that we first think of is the alcohol wine and beer. That alcohol is called ethanol. Ethanol has 2 carbon atoms ("eth"), and the alcohol suffix ("anol"). With 2 carbons, the -OH group can be attached to either carbon atom, but the same molecule forms. There is no need to number the carbon atom that the -OH group attaches to, unless the molecule has at least 3 carbon atoms.

For these 3 alcohol molecules we use prefixes and then the "anol" suffix to name them. Below is methanol, a 1-carbon alcohol, then ethanol, and finally propanol, but correctly it is 1-propanol.



At left is 2-propanol,
the alcohol is attached to
the 2nd carbon atom of three.

Ethers

Ethers are molecules that have a “left side and a right side” and are connected by one oxygen atom, a kind of “oxygen bridge”. They are easy to recognize, with that one oxygen atom in the center, and we name each side chain in alphabetical order. Since the molecules can turn in space, there really is not a left and right side, there are just 2 sides.

To name ethers we first need to discuss “alkyl groups”. A molecule like methane, CH_4 is fully bonded and can't be bonded to another atom like oxygen, UNLESS one hydrogen atom is removed. CH_3 is not methane anymore, we call it a “methyl” group, which means it is like methane, but not quite. The missing H leaves a bond open to bond to oxygen in an ether.

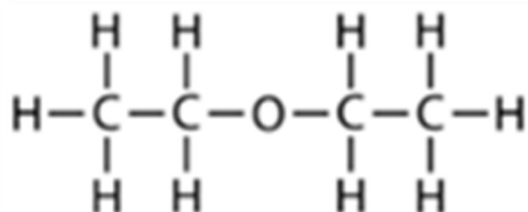
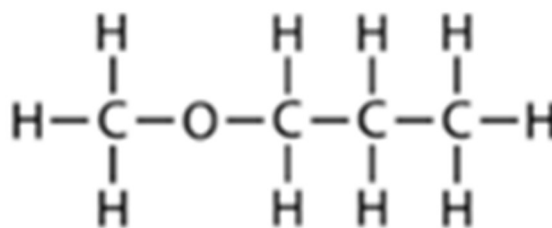
Ethane is C_2H_6 , and it can't bond to oxygen either. But if one H atom is removed, there is an opening to bond to oxygen, but it's not ethane anymore, it's an “ethyl” group.

All alkanes can have one H atom removed (from the end carbon atom) and their names are methyl, ethyl, propyl, butyl, pentyl, hexyl, heptyl, octyl, nonyl and decyl.

We can attach these to oxygen atoms to make a wide variety of ethers. The smallest ether molecule has just a single carbon on either side of the oxygen atom (dimethyl ether). The largest ether in high school has ten carbon atoms on both sides (didecyl ether)

The smallest ether, 1 carbon on either side, to the largest ether which has 10 carbons chained together, on each side, are possible in our class. For naming, put the “alkyl groups” in alphabetical order.

On the right is methyl propyl ether
(1 carbon and 3 carbon chains attached
to the central oxygen atom).
Methyl comes before Propyl in the dictionary.



On the left is diethyl ether
(we don't double up the names;
ethyl ethyl ether sounds funny).

Below are “condensed structural diagrams, not really diagrams but not really formulas either. See if you can draw them and name them. Answers at the bottom of the page. Note the bonds to the oxygen atoms are drawn a bit longer to help us SEE the molecule better.



diethyl ether (right)

methyl propyl ether (left)

Ketones

Ketones contain a double bonded oxygen to a carbon. The carbon is attached on both sides to other carbon atoms or what are called "R" groups. R is for radical, but R means hydrocarbon groups.

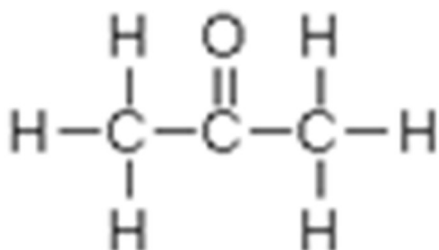
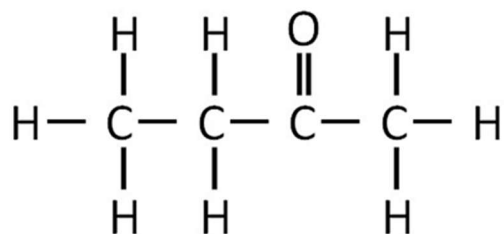
This is a simple ketone, with 4 carbons.

It is called 2-butanone.

The "2" is required because the oxygen atom is double bonded to the 2nd C atom in the short chain.

"But-" is the prefix, because there are 4 carbons in this chain.

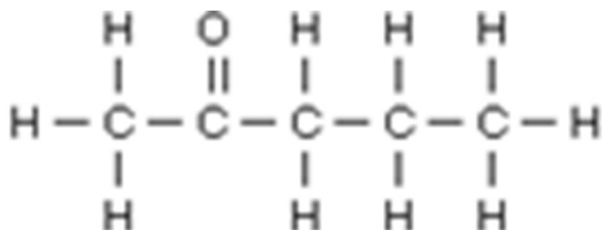
All ketones end with the suffix "-anone".



Here is propanone with 3-carbon atoms. Since all ketones have the oxygen double bonded to a carbon that is located centrally in a molecule, this molecule does not have to have a number, if it is a ketone, the double bonded oxygen atom **HAS TO BE** on carbon #2, you don't have to say it again!

This is 2-pentanone.

The double bonded oxygen is attached to the 2nd carbon in this chain. This **WOULD NOT** be called 4-pentanone. **ALWAYS** name molecules using smaller numbers than larger.

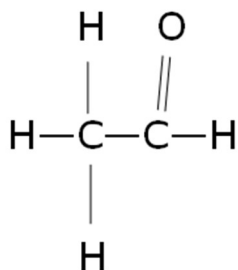
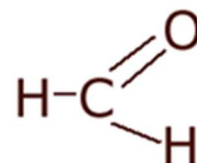


Aldehydes

When the ketone seems to be hanging off the end of a chain, the difference is subtle, but this is a new kind of functional group. An aldehyde has a carbon atom with a double bonded oxygen, but carbon with this double bonded oxygen atom is **ALWAYS** at the end of a chain.

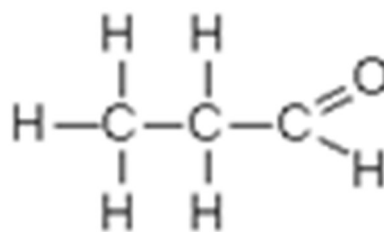
A common aldehyde from bio is formaldehyde.

That is its old-fashioned name. The 1-carbon aldehyde is called methanal.



The aldehydes are named by the number of carbon atoms in the chain. This is **ETH**anal, a 2-carbon chain, with the aldehyde suffix. No numbers for aldehydes ever, the function group is always on the "end" of the chain.

This is a 3-carbon aldehyde called propanal.
No numbers are needed for any aldehydes,
all the aldehyde groups must be on the end carbon
(the #1 carbons) in the chain.



Organic Acids

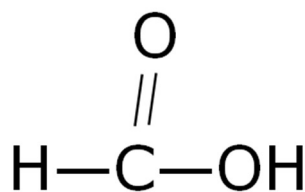
Acids were covered earlier in chemistry, but these acids are the “organic acids” and we use a slightly different naming system with them. They release hydrogen ions in aqueous solution, but the part that is not the acid is a hydrocarbon chain rather than a single anion or tiny polyatomic anion.

The most common organic acid is ethanoic acid, which we learned is the same thing as acetic acid. The formula for acetic acid is $\text{HC}_2\text{H}_3\text{O}_2(\text{AQ})$ and that is the same number of atoms as $\text{CH}_3\text{COOH}(\text{AQ})$, but it is written differently. Acetic acid is ethanoic acid. Both are the exact same molecules, just different ways to imagine it. They have the same number of atoms of each kind, but they are expressed differently on paper.

The organic acid group is called a “-COOH” group. The carbon is double bonded to an oxygen atom, and is also single bonded to an -OH group. This -OH group is part of the acid functional group, and is not to be considered an alcohol, or ketone, or aldehyde group.

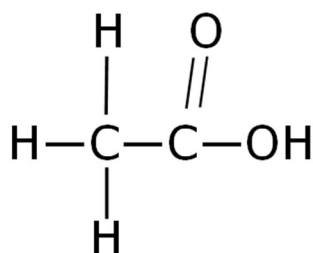
These are the one carbon, two carbon, and three carbon organic acids.

Methanoic Acid



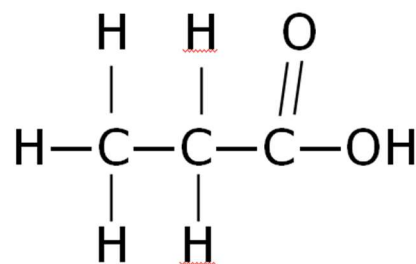
HCOOH

Ethanoic Acid



CH_3COOH

Propanoic Acid



$\text{CH}_3\text{CH}_2\text{COOH}$

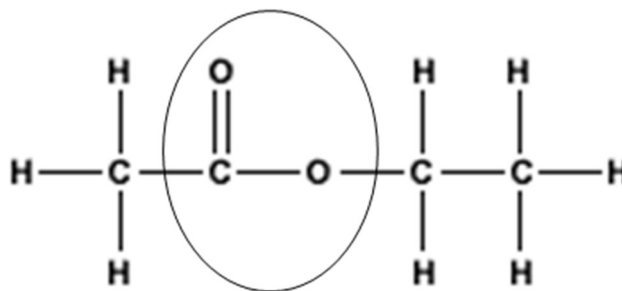
The number of carbons sets the acid PREFIX, and the suffix is always -anoic Acid.

The rest of the organic acids you must recognize are called: butanoic, pentanoic, hexanoic, heptanoic, octanoic, nonanoic and decanoic acid. All have that -COOH group at one end.

It is the “H” in the -COOH group that is the particular hydrogen that forms the H^+ ion in solution, making each follow the Arrhenius acid rule.

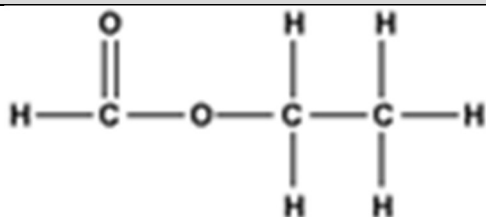
Esters

Esters are the nicest or worst smelling organic molecules. They always have a COO group, bonded in an “L” shape in the center of the molecule, with hydrocarbon chains on either side. At right is a simple ester. Circled is the central “COO” group.



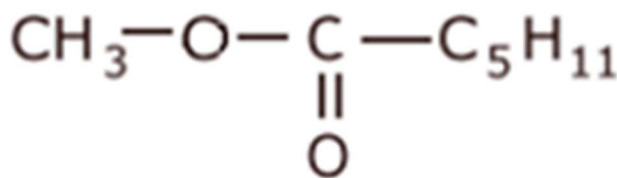
You can make an “L” with your hand, and the hydrocarbons that hang off of the “thumb” or single oxygen atom make the first name.

The first name is the part that’s attached to the single “O” atom, so ethyl is the first name. The 2nd name is the “back side”, also has 2 carbons, would be ethanoate. This is ethyl ethanoate.



Here is a different ester, with an ethyl group attached to the oxygen (thumb side), but only ONE carbon attached to the back side. This is ethyl methanoate.

This 3rd ester is drawn “upside down” compared to the others. This is the ester that makes bananas smell like bananas. The oxygen (thumb side) is a methyl group. The back side is a total of 6 carbons.

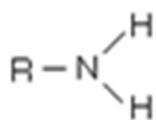


This is methyl hexanoate.

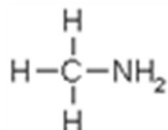
Amines

Amines contain nitrogen. Nitrogen can make and must make 3 bonds. The amine group can be added anywhere to a carbon (like an alcohol group) and therefore are usually numbered to show exactly where in the compound they are. Often the nitrogen atom is attached to just 2 hydrogen atoms.

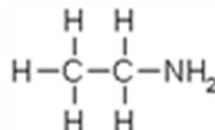
Chains attached are often abbreviated as “R” chains. An “R” chain is a hydrocarbon chain. One is the “R” chain, a second one in the same molecule would be R’ and read as “R PRIME”. In our class to keep things simple we will only attach “H” atoms, not additional R chains.



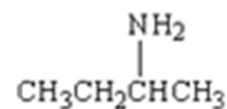
functional group



methanamine



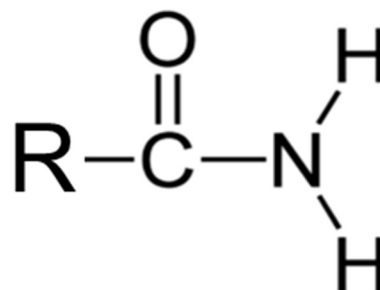
ethanamine



2-butanamine

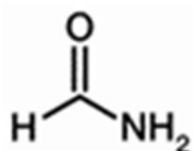
Amides

Amides are like amines but with a clear difference. The carbon that attaches to the -NH_2 group must also be attached to an oxygen atom by double bond. This is shown here; the R group can be of any length and is named by the R group. Amides are always on the “end” of a molecule, no numbering is needed.

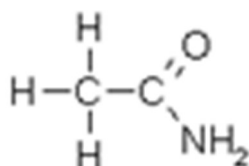


Amide groups are always at the end of the chain, they can't “fit” in the middle of a chain. Because of that, no numbers are ever used, amides attach to the first carbon in every molecule.

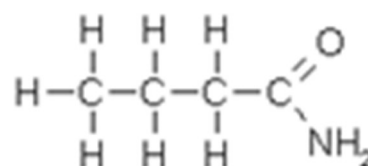
Examples here are the one carbon amide, the two carbon amide, and the four carbon amide.



Methanamide has 1 C



Ethanamide has 2 C



Butanamide with 4 C

Alkyl Groups

More possibilities exist to make our organic molecules more complex (and fun to name). Also able to attach to hydrocarbon chains are shorter chains, usually 1, 2 or 3 carbons in length, but any size group is theoretically possible. Long chains can attach to esters or ethers as well.

A molecule of methane is CH_4 . A molecule of ethane is $\text{CH}_3\text{-CH}_3$. Propane is $\text{CH}_3\text{-CH}_2\text{-CH}_3$.

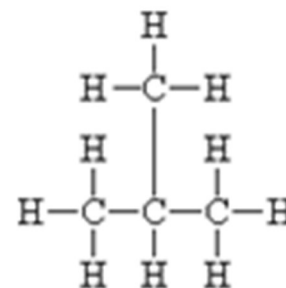
By removing a single hydrogen atom from each, the rest of that group can attach, and these are the methyl, ethyl, and propyl groups. -CH_3 $\text{-CH}_2\text{-CH}_3$ $\text{-CH}_2\text{-CH}_2\text{-CH}_3$

Where the missing H atom opening is, that is how these groups bond to other chains.

These are the alkyl groups we use in high school: methyl, ethyl, propyl, butyl, pentyl, hexyl, heptyl, octyl, nonyl, and decyl (1 to 10 carbon atoms long).

These groups can attach to longer hydrocarbon chains, or functional groups, alone or in pairs or even groups. We name them alphabetically, and by numbering the carbons in the base chain.

This molecule at right is methyl propane, because there is a methyl group attached to the central carbon in a 3-carbon chain (the propane part). The LONGER bond between the methyl group and the propane part is just visual.

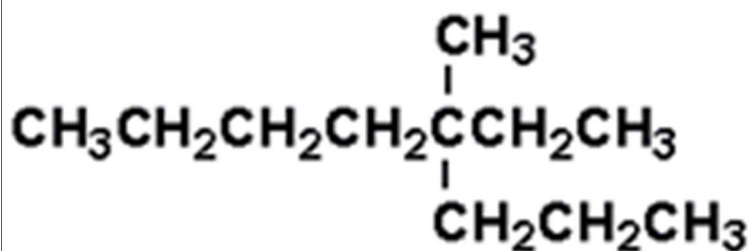
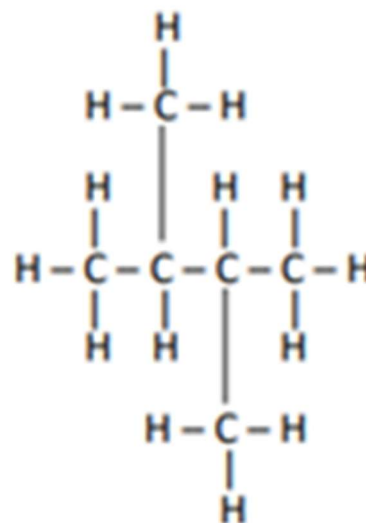


In a 3-dimensional molecule there is less distortion of shape. That bond is like the other C-C bonds in the molecule.

At right is a hydrocarbon with a 4 carbon chain,
with two methyl groups attached.

This is 2,3 dimethyl butane →

The 2,3 indicate two methyl groups attach
to the second and third carbons of the butane chain.
We say “dimethyl” rather than 2 methyl, 3 methyl,
so we don’t sound silly.



Above is a much bigger branched-chain hydrocarbon. The longest chain is 8 carbons, left to right, down and to the bottom right corner. That means that connected from the 4th carbon (the only C with no hydrogen atoms next to it) has a methyl group above and an ethyl group to the right.

This is 4-ethyl, 4-methyl octane

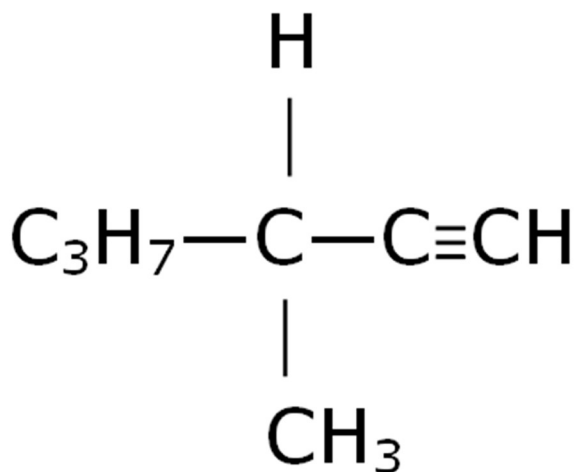
This last one is 3 methyl,1-hexyne.

The methyl group is attached to
the 3rd carbon in a chain with a triple bond
on the number one carbon.

Rule: name the longest chain, here 6 carbons
with a triple bond from #1 to #2.

The last name is 1-hexyne.
The methyl group is attached to the third carbon.

This is 3 methyl-1-hexyne



Organic Reactions

There are many organic chemical reactions to learn about, but we will focus on six of them. As a reminder, you already are supposed to remember these... synthesis, decomposition, single replacement, double replacement, combustion, and acid base neutralization.

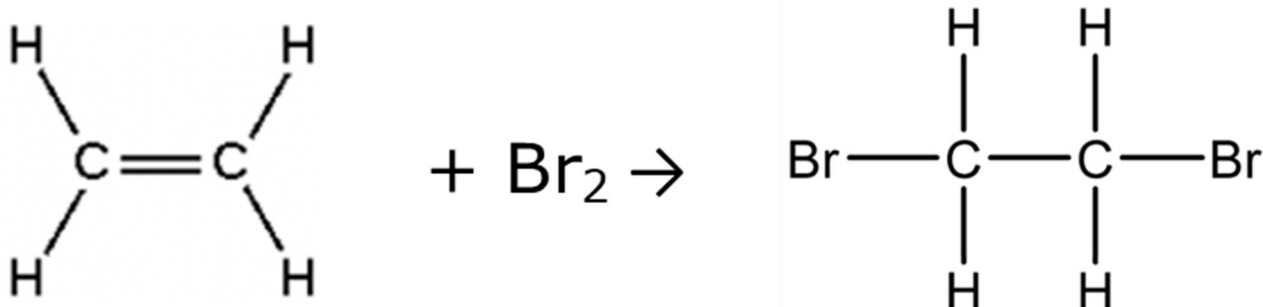
The additional Organic Reactions you need to learn are ADDITION, SUBSTITUTION, ESTERIFICATION, POLYMERIZATION, FERMENTATION, and SAPONIFICATION.

Here goes...

Addition Reactions

When an unsaturated hydrocarbon (alkenes and alkynes) combines with halogen molecules (F_2 , Cl_2 , Br_2 , or I_2) they can join together and combine into a bigger molecule.

A double bond will open, allowing a pair of atoms to join the molecule. For example, ethene can open up and allow a halogen molecule to join, one halogen atom bonds to each carbon, as follows:



NOTE: one bromine atom joins each carbon that was part of the double bond that opened up. Both bromine atoms would not join just one carbon atom.

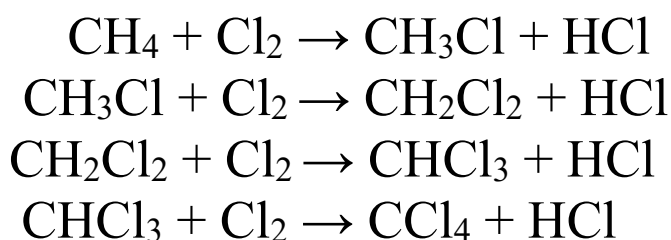
This addition process would work with a triple bond opening to become a double bond, allowing a pair of atoms to add into the original molecule. You could add any diatomic halogen, or H_2 molecule.

Addition works only with unsaturated hydrocarbons. It lets 2 atoms of a halogen or H_2 add into the alkene or alkyne. Trying to add a single atom would leave a carbon atom “unbonded”, which would be so unstable that the reaction would not likely even happen.

Substitution Reactions

If you have saturated hydrocarbon (alkanes) and wanted to add in halogen atoms to it, the alkane could not accept any more atoms into the compound. Alkanes are SATURATED, they are already all full up. Rather than add the new atoms in, they let a single halogen atom substitute for one of the H atoms.

This works only for ONE ATOM per reaction cycle. Watch how methane takes in chlorine through four reactions, and forms new halocarbons each time.



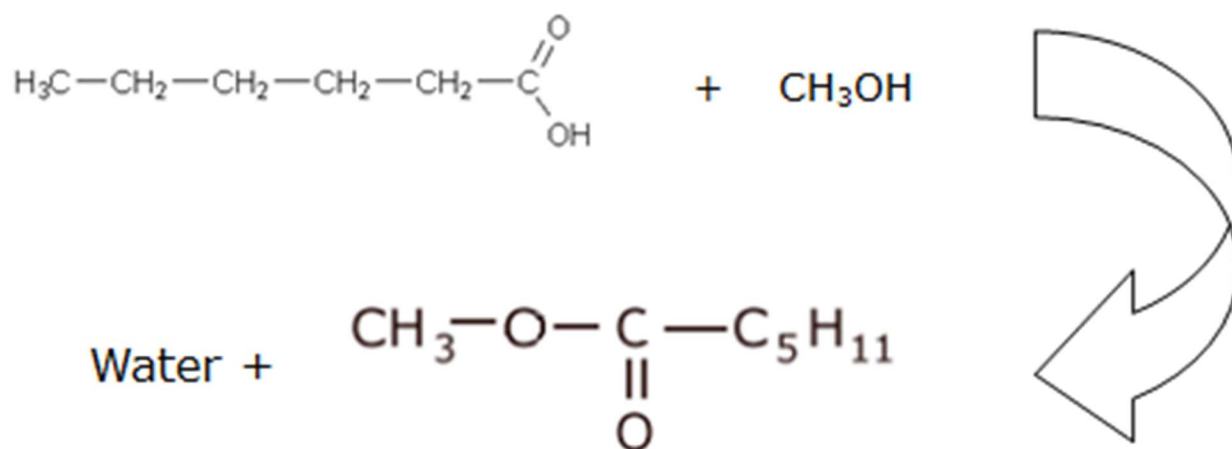
Only one atom of chlorine can be substituted into the alkane at a time. Each time the “bumped out” H atoms will bond with the leftover halogen atom.

Esterification Reactions

The formation of esters is wonderful, as many of them make our favorite smells, such as banana, berry, flowers, etc. To make an ester, this is the simple version:



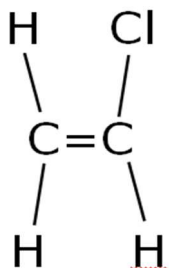
Water is removed by this reaction. When water is removed in a chemical reaction, this can also be called a dehydration synthesis reaction (the removal of water).



Methyl hexanoate is what makes bananas smell like bananas.

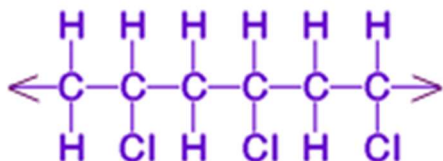
Polymerization

Poly means many. “Mer” means units or bodies. A polymer is a long chain of repeating units, all bonded together. Many plastics are polymers, such as polyethelene, polyester, poly vinyl chloride, Kevlar, Teflon, polystyrene, etc. Normal polymers, such as polyethelenes are about 2000 units long. They form fibers, that weave together, creating a variety of plastic substances.



Chloroethene is a compound that can be induced to break open the double bond between the carbons.

If this happens to many chloroethenes, all at once, they will all form chloroethane, and link up, one right after another, creating PVC, AKA polyvinylchloride plastic (the white plastic plumber’s pipe).



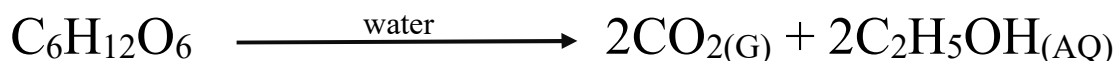
3 units of chloroethane are shown linked here. The double bonds open up to the right + left then they all link into a chain of indefinite length. This allows for the POLY-mer to grow longer. Polymers can be of an length.

Fermentation

The process of fermentation has had profound effects on all societies of the world. Since being discovered, man has been making alcohol to consume. This has led to the gamut of celebration to disease and death, social and religious experiences to violence, to temperance and outright banning, to boot legging. It's all organic chemistry to those educated enough to grasp it. You are that bright and that educated.

Sugars can be broken down by yeast, in a non-aerobic energy release, called fermentation. The waste products of this energy-producing reaction are carbon dioxide and ethanol. They end up dissolved in the water required by the yeast. Ethanol is the only kind of alcohol that people can consume. Proper balance of sugar and fruit flavors, and time, yields cheap or expensive champagnes, and other alcoholic solutions.

Although this is very well controlled by humans, they still need the yeast to do the real work! The yeast provides the enzymes that break down the sugars to release energy.

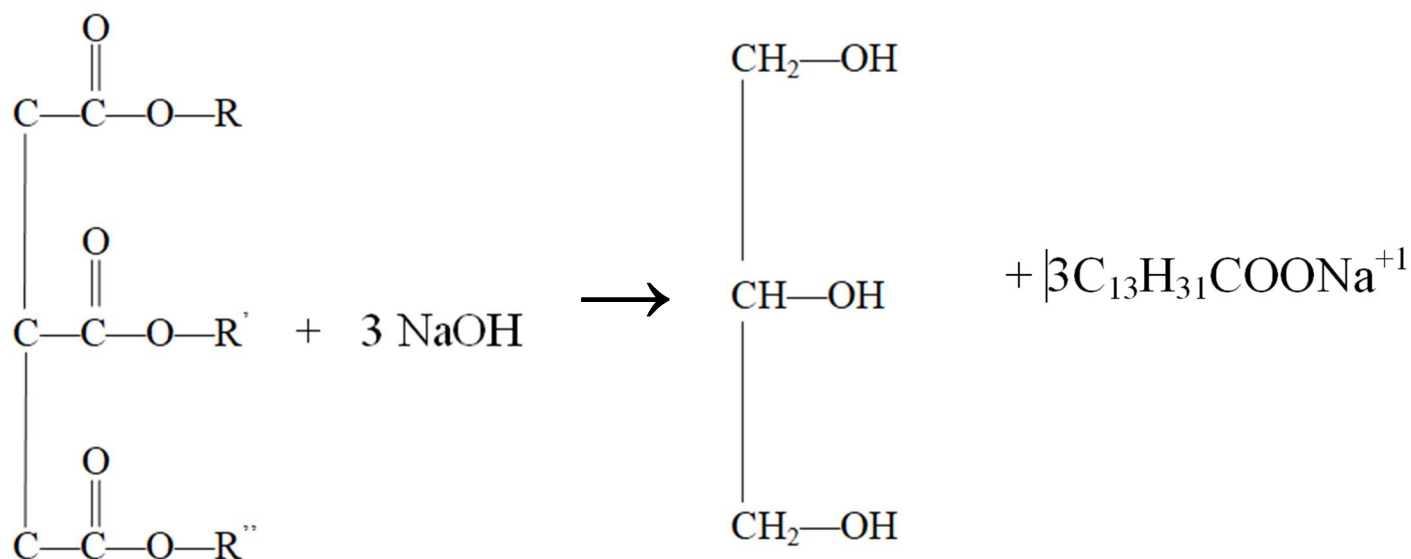


We will use the fermentation of glucose to be our example. Many other types of sugars like fructose, maltose, etc. are fermented, the balancing is complicated and we're only peeking at fermentation.

Saponification

If you misspell this reaction and type the first four letters this way: S-O-A-P, you will remember that this reaction produces soap. It's that easy, and that difficult!

A triple ester combines with three strong bases (3 KOH or 3 NaOH, etc.) which yields a triple alcohol plus SOAP. Soap reactions are complex.



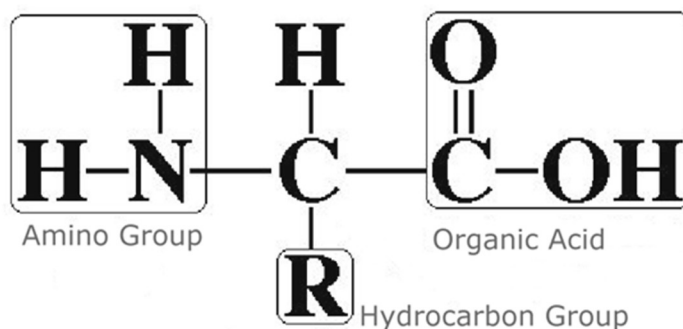
Triple Ester and three BASES form into a Triple Alcohol + 3 SOAP molecules (with a CATION!)

Learn to recognize the TRIPLE ester, TRIPLE alcohol and REMEMBER SOAP = SAPONIFICATION.

Amino Acids

Making amino acids are also a bit outside our class, but what they are is not. Amino acids make up proteins and all of the most important chemistry of living organisms. They combine an amine group compound with an organic acid.

This slide is from the internet, it is excellent in simplicity and clarity. Open your brains up now...

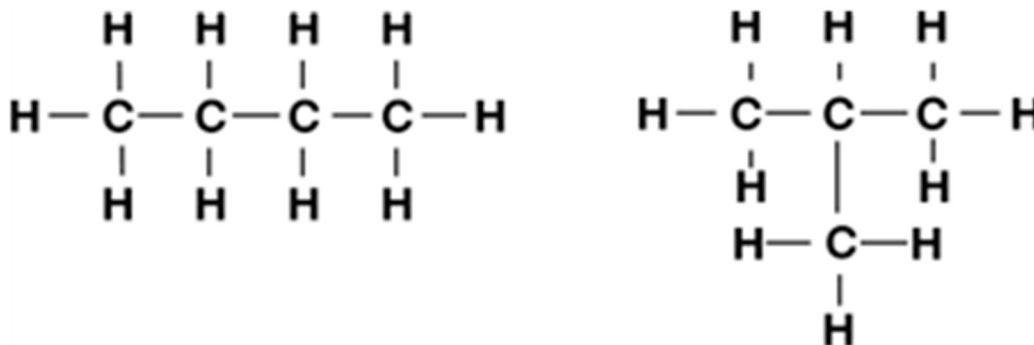


More VOCABULARY WORDS...

ISOMERS are organic molecules that share exact chemical formulas (molecular formulas) and therefore have the exact same numbers of the same atoms in their individual compounds, but they have DIFFERENT STRUCTURES, which also give different properties.

Examples: Butane can be drawn as a straight chain, or as a branched chain. The straight chain can be called n-butane (for normal). The second compound can be called isobutane (isomer of butane).

We call these butane and methyl propane by IUPAC formal rules.



Hexane 6 C atoms & 5 isomers (try to draw them!)	n-hexane (normal or straight-line molecule)	2 methyl pentane (one branch)
3 methyl pentane (a different branch)	2,3 dimethyl butane (two branches)	2,2 dimethyl butane (different two branches)

Isomers, continued

The hydrocarbon alkane called decane $C_{10}H_{22}$ has 75 isomers. Icosane is $C_{20}H_{42}$ and it has 366,319 isomers. $C_{30}H_{62}$ has an incredible 4,111,846,763 isomers! (that's BILLIONS!) Not all isomers been created, but they are all possible!

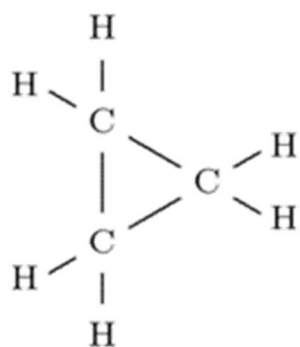
Imagine adding in a few halogen atoms here and there, or functional groups, or multiple functional groups. Organic chemistry is (more or less) ENDLESS!

Other important isomers include ETHERS and ALCOHOLS. If the ether and alcohol have the same total number of carbon atoms (they will have the same number of H atoms too) and they are isomers of each other.

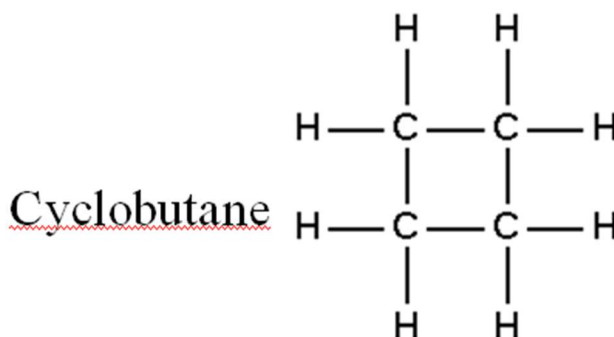
2 carbon atoms	Dimethyl ether CH_3OCH_3	Ethanol - C_2H_5OH
3 carbon atoms	Methyl ethyl ether $CH_3OCH_2CH_3$	Propanol - C_3H_7OH
4 carbon atoms	Diethyl ether $CH_3CH_2OCH_2H_3$	Butanol - C_4H_9OH

Ring Hydrocarbons

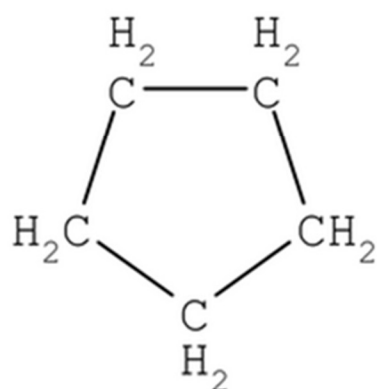
Besides chains and chains with functional groups, hydrocarbons can form rings of various sizes, say 3, 4, 5, or 6 or more carbons all bonded together with single or double bonds. Various functional groups, methyl, ethyl, etc. groups can also bond. This is not part of our class, but really neat and important to organic chem as well. The prefix cyclo- is used.



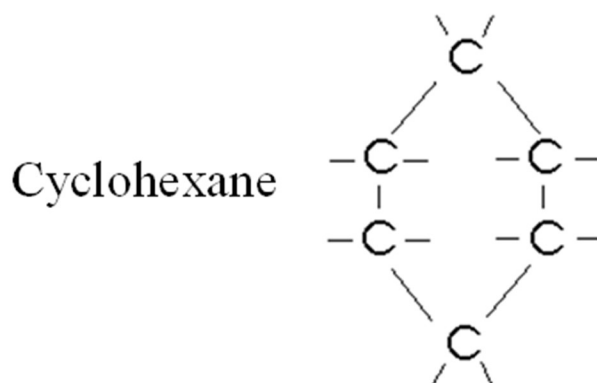
Cyclopropane



Cyclobutane



Cyclopentane



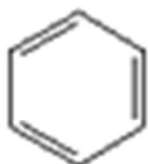
Cyclohexane

Benzene Rings

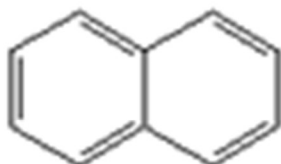
are extremely important to organic chem but again, not to our class. This is optional but worthwhile.

Benzene is a 6 carbon ring structure with alternating double and single bonds. These bonds “resonate” back and forth with each other constantly. They act as if there are always $1\frac{1}{2}$ bonds between each carbon.

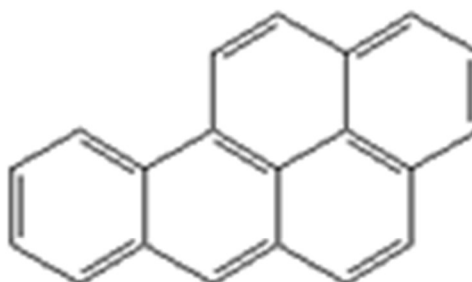
The benzene rings combine with all sorts of groups and other rings. Here are a few examples.



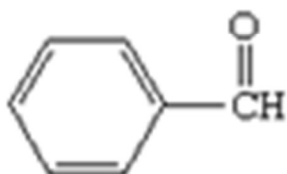
benzene



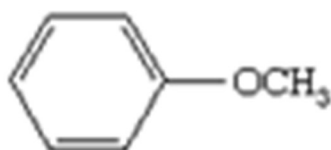
naphthalene



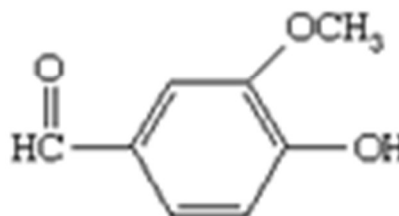
benz[a]pyrene



benzaldehyde

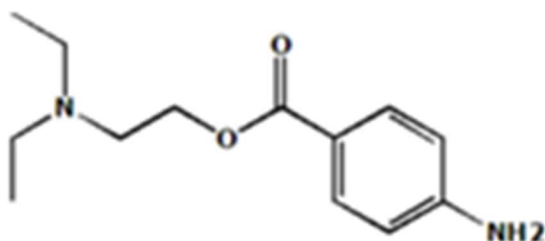


anisole



vanillin

Below is NOVOCAINE, what your dentist gives you when you need a filling. You should recognize all parts of this molecule, with all the hidden carbons & hydrogen atoms.



Below is EPINEPHRINE, the chemical that gets pumped into your blood when you are confronted with a wild dog about to bite you, or when you get nervous before your first high dive! Double bonds, alcohols, a benzene ring, etc. You recognize it all too, even if naming this funky molecule is difficult.

It's all just C, H, O, N, and some single and double bonds.

Organic chem is everywhere!

