Mr. Kent's Organic Chemistry Unit Notes

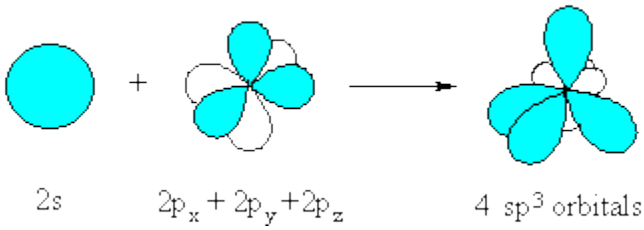
I Basic Concepts

A. Organic Chemistry-The study of _____ containing compounds.

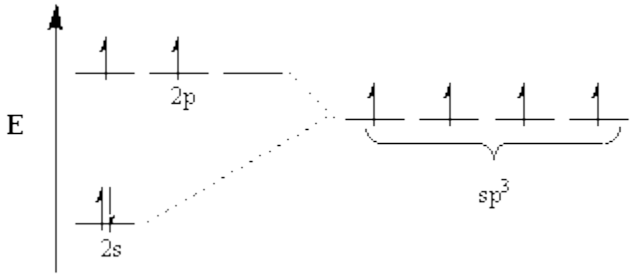
1. They occur extensively in nature because all living things are made of _____ containing compounds.

II Bonding

A. _____ can form _____ covalent bonds (_____hybrids consisting of 1_____ orbital and 3_____ orbitals)



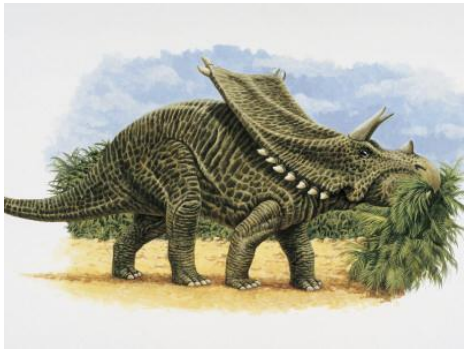
When hybridized the 4 different orbitals are combined and create 4 equal energy orbitals.



B. _____ will not only combine with other atoms, but will also bond with other _____atoms making for very large numbers of molecules.

C. Organic compounds are more numerous than _____ compounds.

D. A major source of organic compounds is _____.
Which came from _____ many years ago.

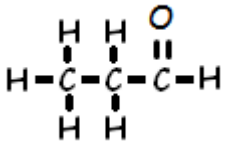
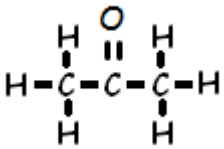


III Characteristics

1. Generally, _____ molecules (SNAP)
2. _____ dissolves in water
   Exceptions _____ & _____
3. Non-_____-generally do not conduct electricity in water, except _____
4. Melting Points are _____ due to _____ intermolecular forces
5. Chemical Reactions are _____ compared to inorganic reactions

IV Some Organic Compounds form _____.

1. Compounds with the same_____ but different _____
2. We draw structural formulas to avoid confusion
3. Example-C_3H_6O

4. As the number of carbon atoms increase, the number of Isomers will _____.

V More bonding

1. Carbon atoms that are bonded together by sharing ____ electrons form a _____bond
2. Carbon atoms that are bonded together by sharing ____ electrons form a _____bond
3. Carbon atoms that are bonded together by sharing ____ electrons form a _____bond
4. _____compounds contain ALL SINGLE BONDS
5. _____ compounds contain NOT ALL SINGLE BONDS, but have double or triple bonds.

VI. Types of Organic Compounds

A. HYDROCARBONS

1. Contain only _____ and _____ atoms.
2. Homologous Series (see table ____)- each sample of a homologous series differs by the previous by ___ carbon and _____hydrogen atoms
3. Boiling Points- As the number of carbon atoms increases the boiling points _____ due to _____ intermolecular forces.

ALKANES- Saturated hydrocarbons

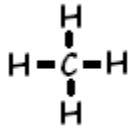
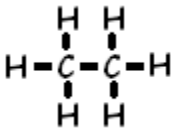
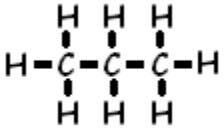
Nomenclature (Naming Rules)- end with “-ane”

General Formula

C_nH_{2n+2}

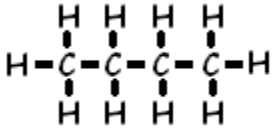
# Carbons	prefix	Molecular formula	Name
1	Meth	CH_4	
2	Eth	C_2H_6	
3	Prop	C_3H_8	
4	But	C_4H_{10}	
5	Penta	C_5H_{12}	
6	Hexa	C_6H_{14}	
7	Hept	C_7H_{16}	
8	Oct	C_8H_{18}	
9	Non	C_9H_{20}	
10	Deca	$C_{10}H_{22}$	

The first 3 alkanes have no isomers (they can only be drawn 1 way).

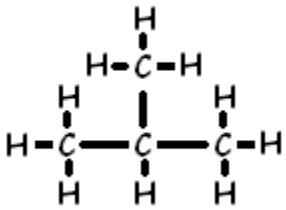
		

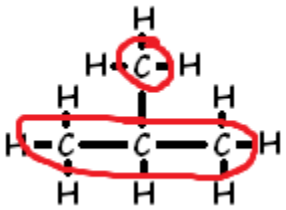
Isomers of Butane C_4H_{10}

Rule #1-Name the longest continuous chain of carbon atoms (with group), and end it with -ane.

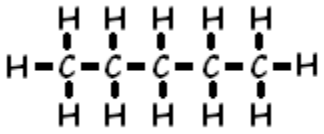
	

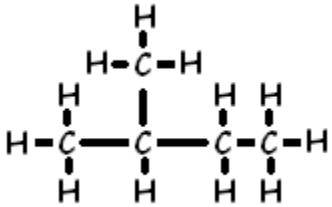
Rule #2- Remaining side chains will be given the ending -yl.

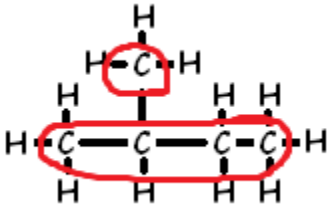




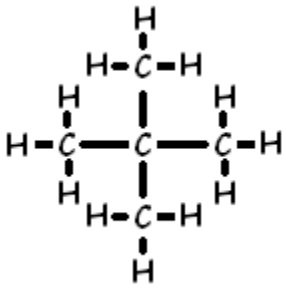
Isomers of Pentane C_5H_{12}

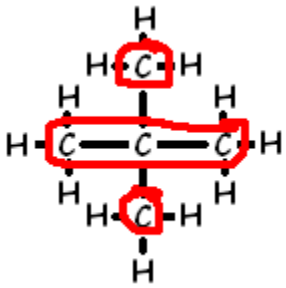




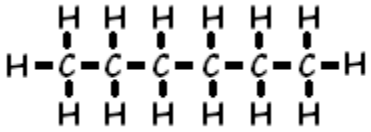
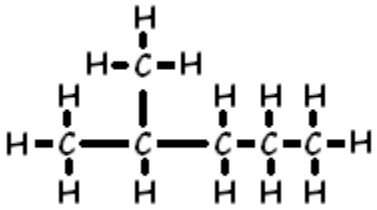
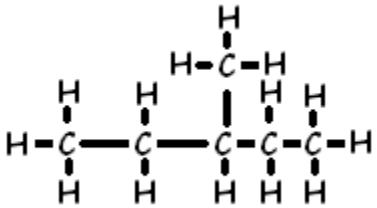


Rule #3- Multiple side chains will use prefixes 2 is di-, 3 is tri-, 4 is tetra- and so on.

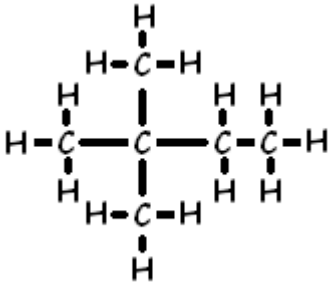




Isomers of Hexane C_6H_{14}

Rule #4- Give the ***lowest number*** location for each side chain if there is another possible location it could be located. Go back and fix the last 2 isomers

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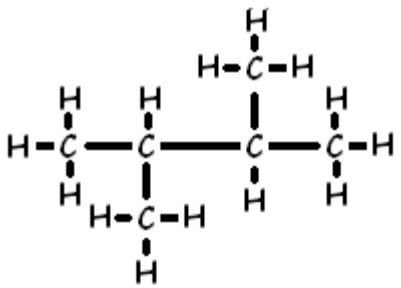
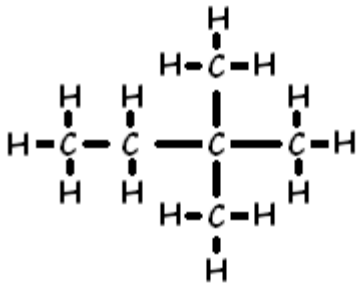
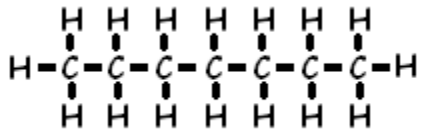
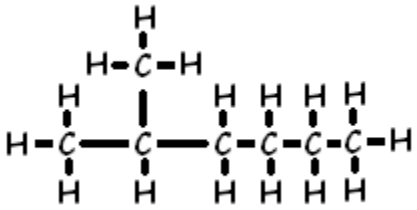
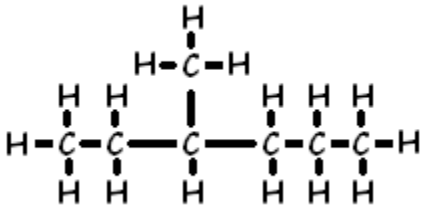
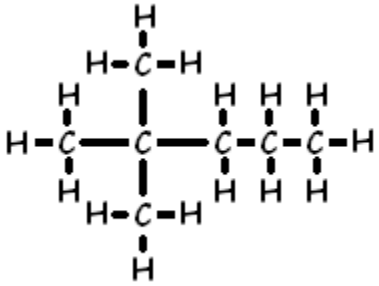
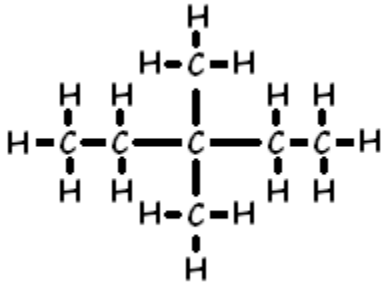
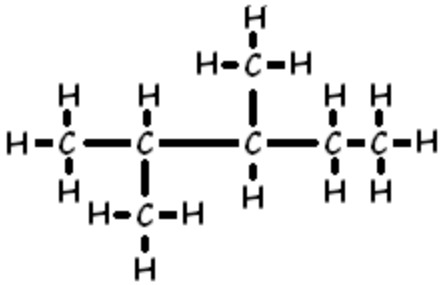
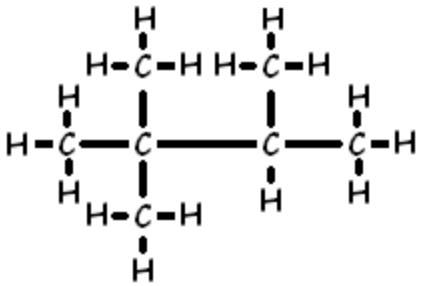
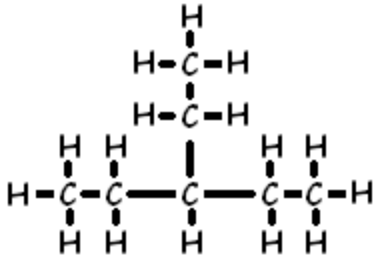
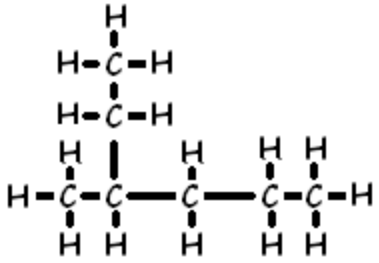
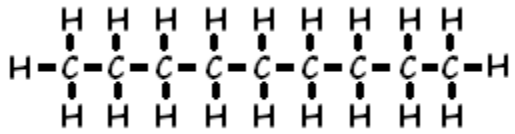
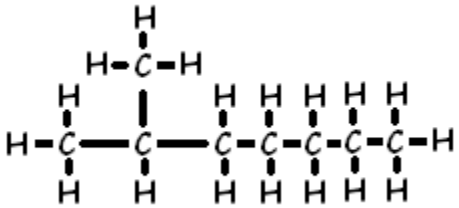
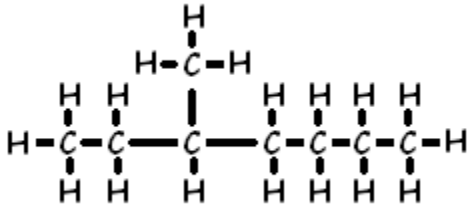
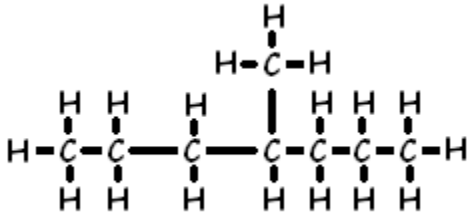
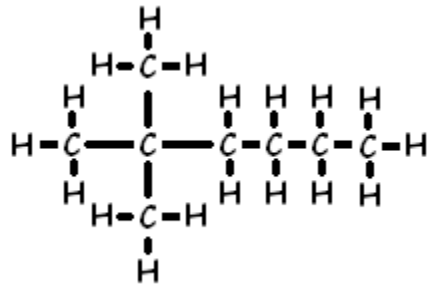
	
	

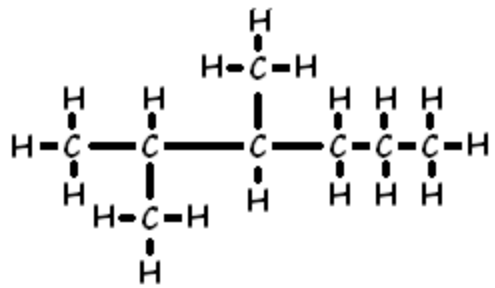
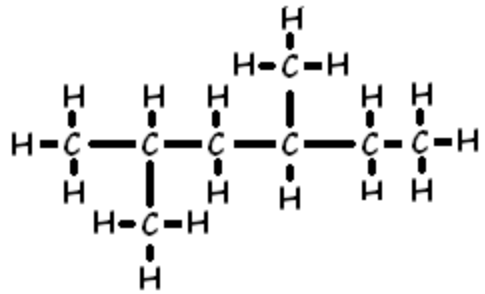
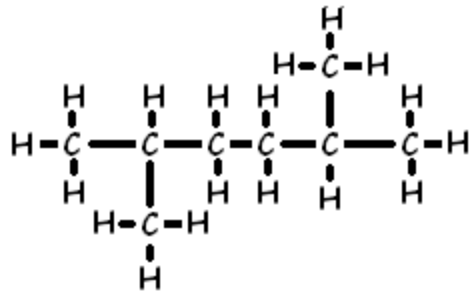
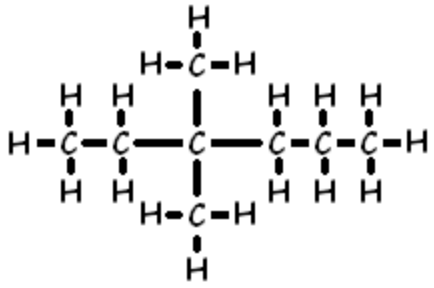
Isomers of Heptane C_7H_{16}

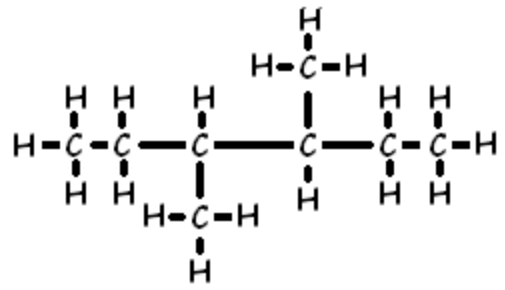
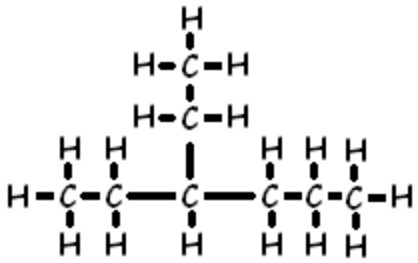
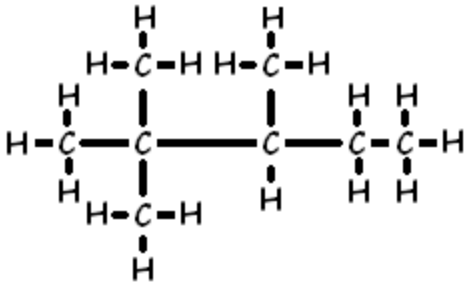
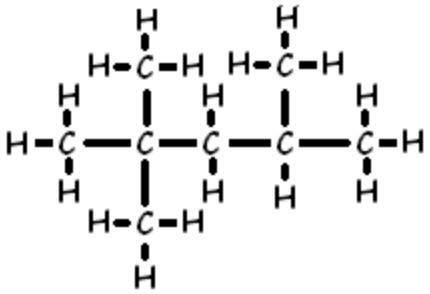
	
	
	
	
	

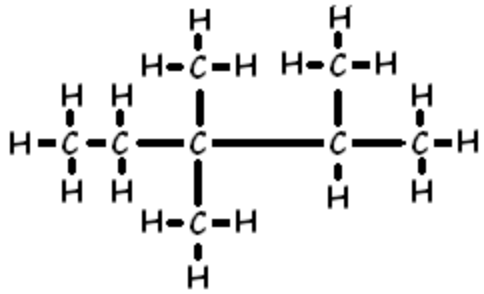
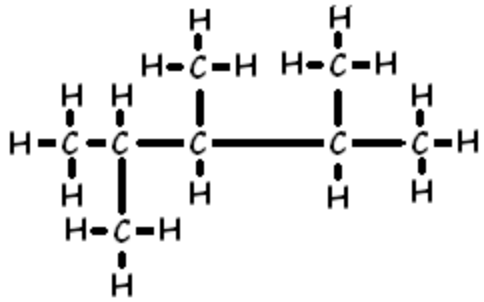
	
	
	
	

Isomers of Octane C_8H_{18}

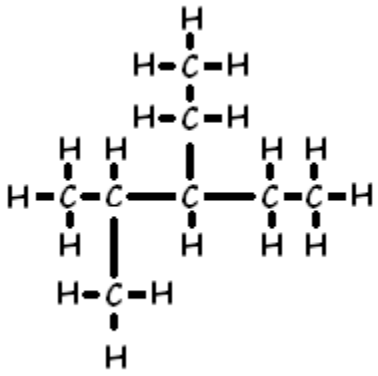
	
	
	
	
	

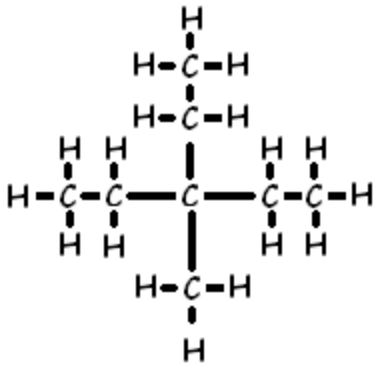
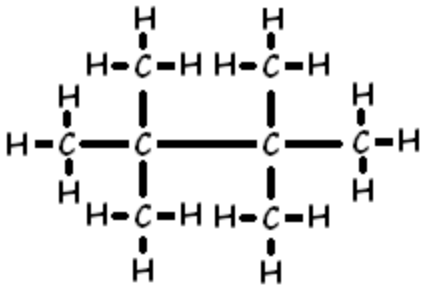
	
	
	
	

Rule #5- When there are 2 different side chains name them in alphabetical order using the carbon prefix (meth, eth..).

2. Alkenes-

A. Are _____ (not all single bonds) hydrocarbons (hydrogen and carbon only) containing 1 carbon to carbon double bond "C=C".

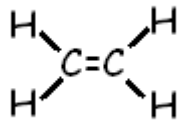
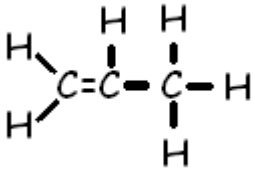
B. The rule for naming is they all end with "-ene".

C. The general formula is C_nH_{2n}, n is the number of carbons is used to determine the number of hydrogen atoms. Example n=5, so H=(2(5))=10

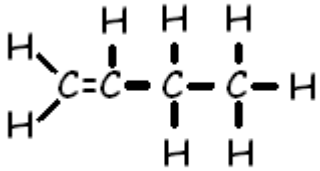
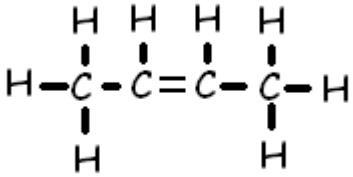
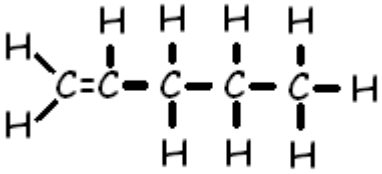
What is the first member of the Alkene homologous series?

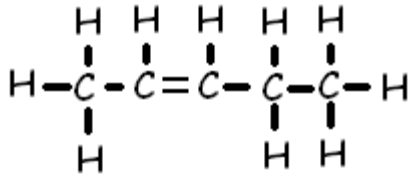
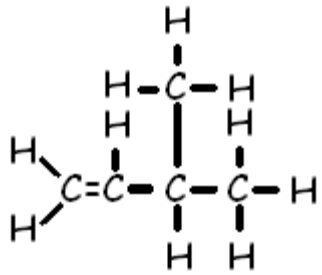
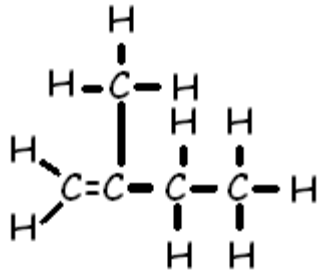
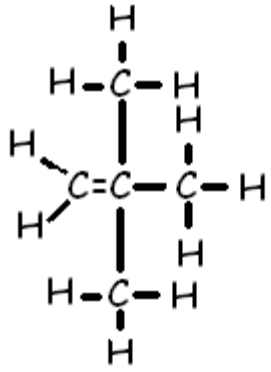
Name_____ Formula_____

Rule #1-Name the longest chain with the double bond. It is not always the longest chain of carbons. End it with "-ene".

C_2H_4		
C_3H_6		

Rule #2-When necessary use the ***lowest*** number to give the location of double bond in the longest chain.

C_4H_8		
C_4H_8		
C_5H_{10}		

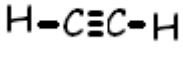
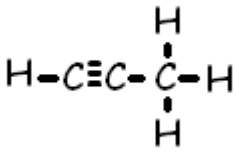
C_5H_{10}		
C_5H_{10}		
C_5H_{10}		
C_5H_{11}		

C. Alkynes- Are _____ (not all single bonds) hydrocarbons (hydrogen and carbon only) containing 1 carbon to carbon triple bond "C≡C".

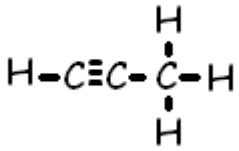
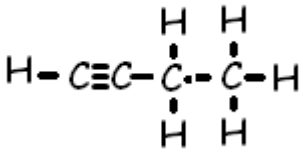
The rule for naming is they all end with "-yne".

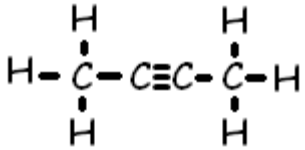
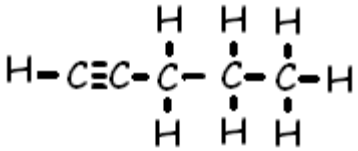
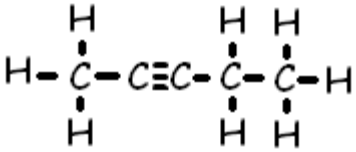
The general formula is C_nH_{2n-2}, n is the number of carbons is used to determine the number of hydrogen atoms. Example n=5, so H=(2(5)-2)=8

Rule #1-Name the longest chain with the triple bond. It is not always the longest chain of carbons. End it with "-yne".

C_2H_2		
C_3H_4		

Rule #2-When necessary use the ***lowest*** number to give the location of triple bond in the longest chain.

C3H4		
C_4H_6		

C_4H_6		
C_5H_8		
C_5H_8		

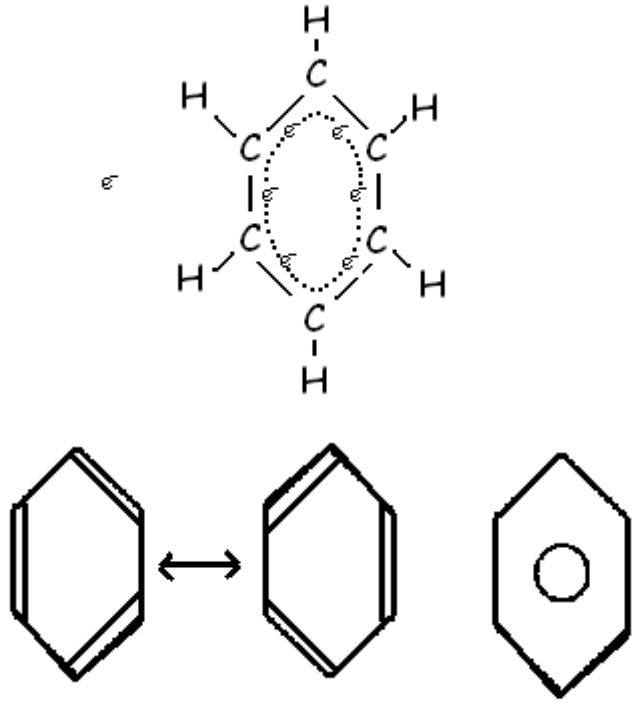
4. Benzenes-

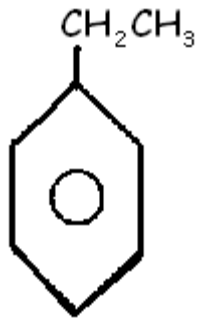
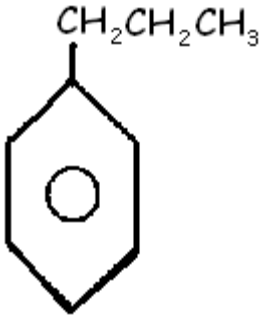
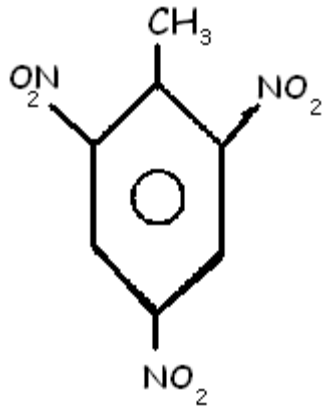
The rule for naming is they all end with "benzene".

The general formula is C_nH_{2n-6}, n is the number of carbons is used to determine the number of hydrogen atoms. Example n=8, so H=(2(8)-6)=10

Rule #1-Name the benzene ring. End it with "benzene".

Rule #2-When necessary use the ***lowest*** number to give the locations of side chains that come off the benzene.

C_6H_6		
C_7H_8		

C_8H_{10}		
C_9H_{12}		
		

5. Other Hydrocarbons

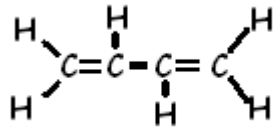
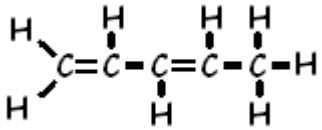
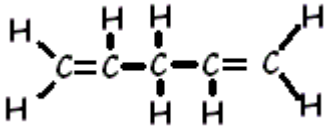
A. Dienes- Organic compound containing 2 separate carbon to carbon double bonds C=C

The rule for naming is they all end with "-diene".

The general formula is C_nH_{2n-2}, n is the number of carbons is used to determine the number of hydrogen atoms. Example n=4, so H=(2(4)-2)=6

Rule #1-Name the longest chain that contains both double bonds. End it with "diene".

Rule #2-When necessary use the ***lowest*** numbers to give the locations of both double bonds.

C_4H_6		
C_5H_8		
C_5H_8		

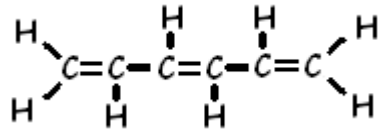
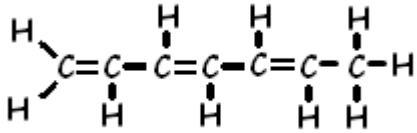
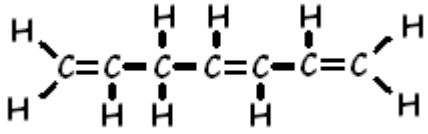
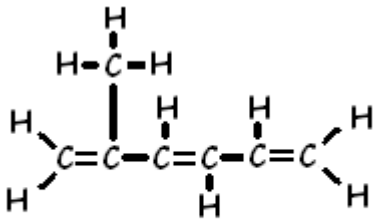
B.Trienes- Organic compound containing 3 separate carbon to carbon double bonds C=C

The rule for naming is they all end with "-triene".

The general formula is C_nH_{2n-4}, n is the number of carbons is used to determine the number of hydrogen atoms. Example n=6, so H=(2(6)-4)=8

Rule #1-Name the longest chain that contains both double bonds. End it with "triene".

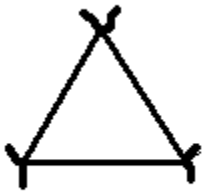
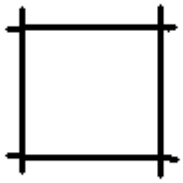
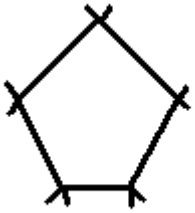
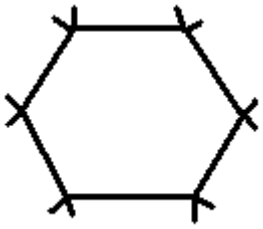
Rule #2-When necessary use the ***lowest*** numbers to give the locations of both double bonds.

C_6H_8		
C_7H_{10}		
C_7H_{10}		
C_7H_{10}		

C. Cyclic compounds-Hydrocarbons in which the 2 ends of the chain are attached at the ends to form a ring

The rule for naming is they all start with "cyclo-".

Rule #1-Name the carbon ring. Start it with "cyclo".

C_3H_6		
C_4H_8		
C_5H_{10}		
C_6H_{12}		

B. Other Organic Compounds

1. Functional Groups-the atom or group of atoms that characterizes the structure of a family of organic compounds and determines the properties

2. Halides

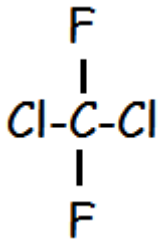
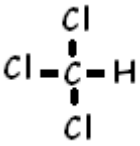
A. An organic compound containing one or more halogen atoms.

B. Nomenclature-Name the halogen like you would any other substituent group.

Chlorine-->Chloro Bromine-->Bromo

Iodine-->Iodo Fluorine-->Fluoro

C. Examples

Name	Structure
	
	

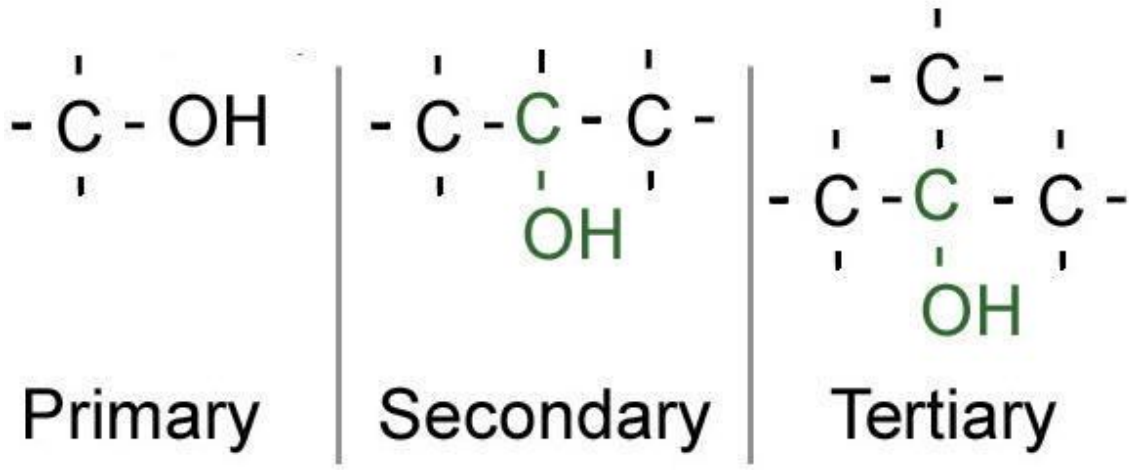
3. Alcohols- are compounds in which one or more hydrogen atoms in an alkane have been replaced by a hydroxyl (-OH) group.

OH- is hydroxide, but in organic chemistry side chains end with "-yl".

R-OH

Types of Alcohols

Monohydroxy Alcohols- contains 1 –OH group

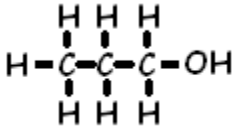


Primary(1°)- the C-OH is attached to one other carbon (on the end)

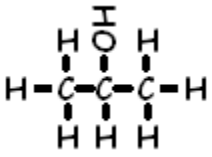
Secondary(2°)- the C-OH is attached to two other carbons

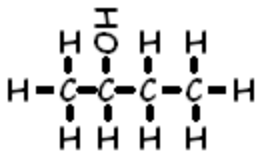
Tertiary(3°)- the C-OH is attached to three other carbons

Primary Example

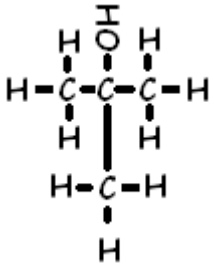


Secondary

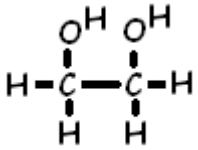




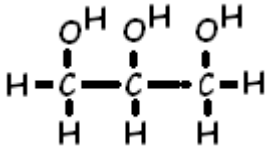
Tertiary Example



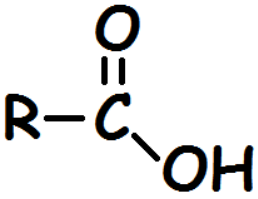
Dihydroxy Alcohols- contain 2 –OH group (ends with -_____)



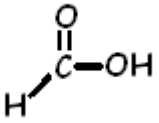
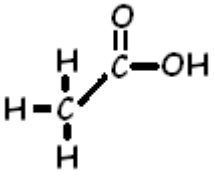
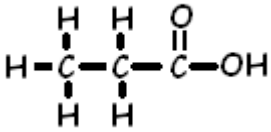
Trihydroxy Alcohols- contain 3 –OH group (ends with -_____)

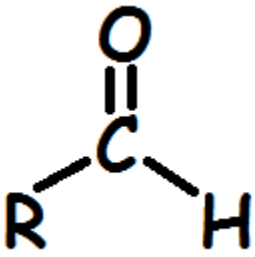


4. Organic Acids- An organic acid is an organic compound with acidic properties. The most common organic acids are the carboxylic acids whose acidity is associated with their carboxyl group -COOH.



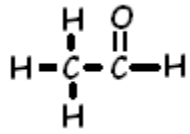
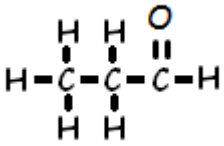
Nomenclature-carboxylic acids have an -oic acid suffix (e.g. octadecanoic acid)

Name	Expanded Structure
	
	
	
Name	Condensed Structure
	$HCOOH$
	CH_3COOH
	CH_3CH_2COOH
	C_4H_9COOH
	$C_8H_{17}COOH$



5. Aldehydes-A compound with a carbon atom which is bonded to a hydrogen atom and double-bonded to an oxygen atom. This is found on the end of the chain, ketones have this carbon in the middle (no H either).

Nomenclature-The name is formed by changing the suffix -e of the parent alkane to -al, so that HCHO is named methanal, and $CH_3CH_2CH_2CHO$ is named butanal.

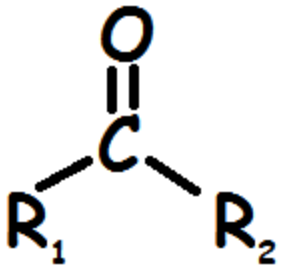
Expanded Structure	Name	Expanded Structure	Name
			

Synthesis

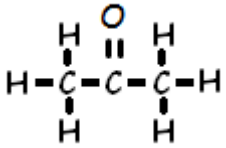
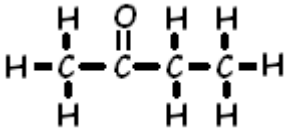
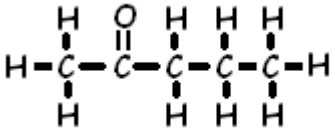
A primary alcohol reacts with an oxidizing agent to make an aldehyde

$$R\text{-}OH + Ox.\ Agent \rightarrow \boldsymbol{R}H{=}O + H_2O$$

6. Ketones- A compound with a carbonyl group (O=C) linked to two other carbon atoms in the chemical compound. The C=O is found somewhere in the middle of the chain (not the end). Three carbons are needed to form a ketone.



Nomenclature- changing the suffix -e of the parent alkane to "-one"

Name	Expanded Structures
	
	
	

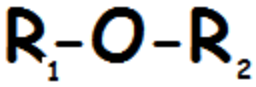
Name	Condensed Structures
	CH_3COCH_3
	$CH_3COCH_2CH_3$
	$CH_3COCH_2CH_2CH_3$
	$CH_3CH_2COCH_2CH_3$
	$CH_3COCH_2CH_2CH_2CH_3$

Synthesis

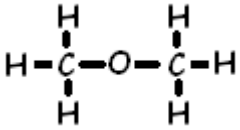
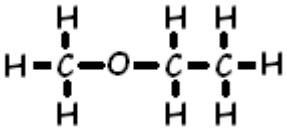
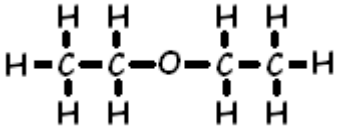
Ketones can be created by oxidation of secondary alcohols. The process requires a strong oxidizing agent.

$$H_3C\text{-}CH(OH)\text{-}CH_3 + \text{ox. agent} \rightarrow H_3C\text{-}CO\text{-}CH_3 + H_2O$$

7. Ethers-a chemical compound where and oxygen atom connects two substituted groups



Nomenclature-Ethers can be named by naming each of the two carbon groups as a separate word followed by a space and the word ether.

Name	Expanded Structure
	
	
	
	$CH_3\text{–}CH_2\text{–}O\text{-}CH_2\text{-}CH_2\text{–}CH_3$
	$CH_3\text{–}CH_2\text{–}CH_2\text{–}O\text{-}CH_2\text{-}CH_2\text{–}CH_3$

Synthesis

Primary alcohols react to produce an ether and water

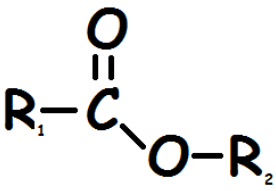
$$\boldsymbol{R}\text{-}OH + R\text{-}OH \rightarrow \boldsymbol{R}\text{-}O\text{-}R + H_2O$$

8. Polymers-composed of many repeating units called monomers

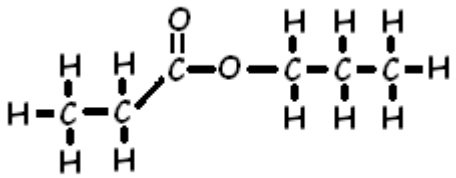
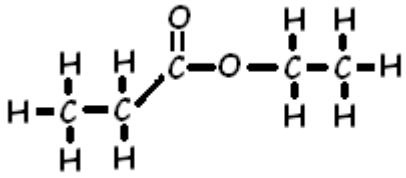
Natural Polymers	Synthetic Polymers

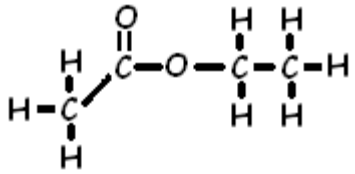
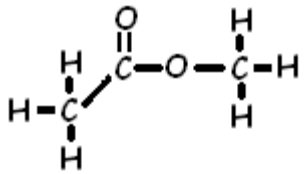
9. Esters

Nomenclature-Esters (R-CO-O-R') are named as alkyl derivatives of carboxylic acids. The alkyl (R') group is named first (the carbon chain from the alcohol). The R-CO-O part is then named as a separate word based on the carboxylic acid name, with the ending changed from -*oic acid* to "*-oate*".

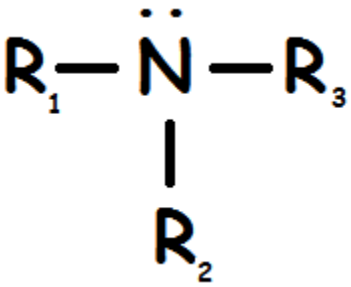


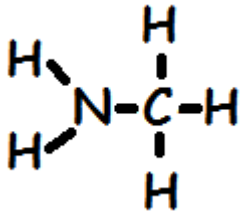
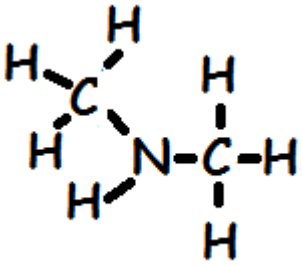
"Alcoholyl acidoate"

NAMES	Expanded STRUCTURE
	
	

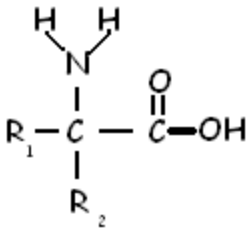
	
	
	$CH_3CH_2CH_2CH_2COOCH_3$
	$CH_3CH_2CH_2COOCH_3$
	$CH_3CH_2COOCH_3$

10. Amines-In amines, the hydrogen atoms in the ammonia have been replaced one at a time by hydrocarbon groups. On this page, we are only looking at cases where the hydrocarbon groups are simple alkyl groups.

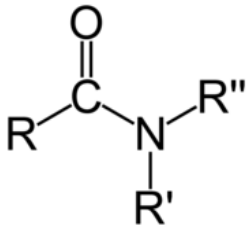


11. **Amino Acids** are the chemical units or "building blocks" of the body that make up proteins. Contain both an amine group ($-NH_2$) and the carboxyl group (-COOH)



12. **Amides**- ($R-CO-NH_2$) take the suffix "-amide". There is no prefix form, and no location number is required since they always terminate a carbon chain, e.g. CH_3CONH_2 is named ethanamide.

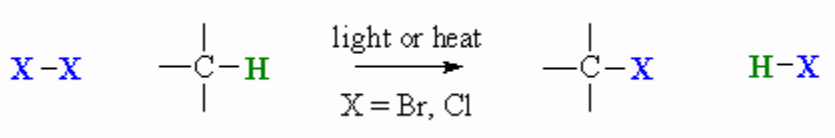


VII. Organic Reactions

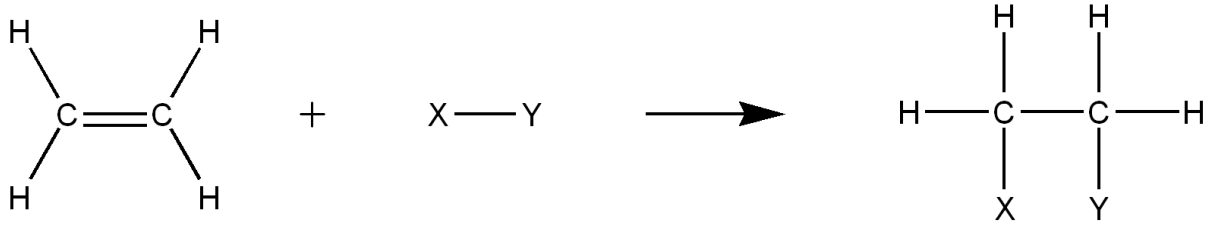
A. Substitution reaction-A functional group in a particular chemical compound is replaced by another

This occurs with a saturated structure.

Saturated, Substitution



B. Addition reaction-A reaction where a pi bond (either a double or triple bond) is replaced with the creation of two new covalent bonds. (for this course you only need to know the term addition and how it works)

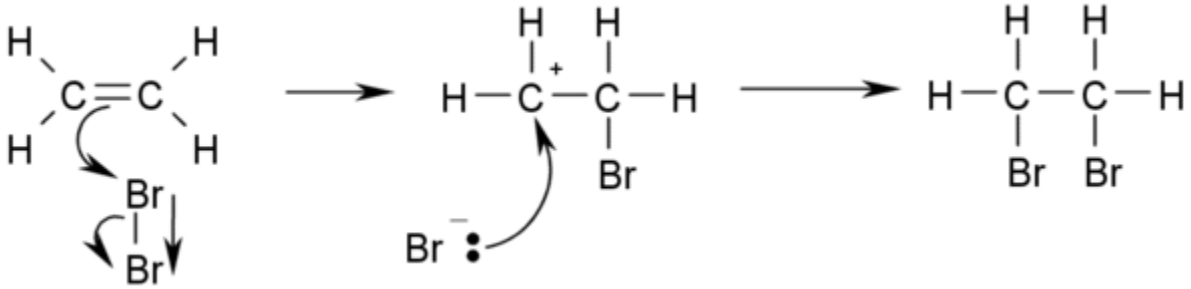


Hydrogenization

$$CH_2{=}CH_2 + H_2 \rightarrow CH_3{-}CH_3$$

Halogenation-bromine or chlorine

$$CH_2{=}CH_2 + Br_2 \rightarrow BrCH_2{-}CH_2Br$$



C. Fermentation

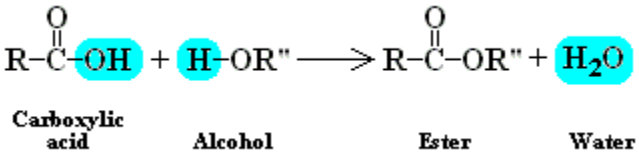
The enzymes in yeast break down sugar (glucose) into alcohol (ethanol) and carbon dioxide gas.

glucose $\xrightarrow{\text{yeast}}$ ethanol + carbon dioxide

$$C_6H_{12}O_6(aq) \xrightarrow{\text{yeast}} 2\ C_2H_5OH(aq) + 2\ CO_2(g)$$

D. ESTERFICATION-is the general name for a chemical reaction in which two chemicals (typically an acid and an alcohol) form an ester as the reaction product (water).

Synthesis-When a carboxylic acid and an alcohol react, a water molecule is removed, and an ester molecule is formed.



E. **Saponification** is commonly used to refer to the reaction of a **fat** (ester) with a metallic alkali (**base)** or oil to form **soap** and **glycerol.**

fat + Base --> soap + glycerol

F. **Oxidation-(combustion)-** Complete combustion (given sufficient oxygen) of any hydrocarbon produces carbon dioxide and water.

$$\_\_\_CH_4 + \_\_\_O_2 \rightarrow \_\_\_CO_2 + \_\_\_H_2O$$

Incomplete Combustion-not enough O_2

$$\_\_\_CH_4 + \_\_\_O_2 \rightarrow \_\_\_CO + \_\_\_H_2O$$

$$\_\_\_CH_4 + \_\_\_O_2 \rightarrow \_\_\_C + \_\_\_H_2O$$

G. Polymerization

1. Joining of _____
2. Condensation Polymerization (evolves _____)

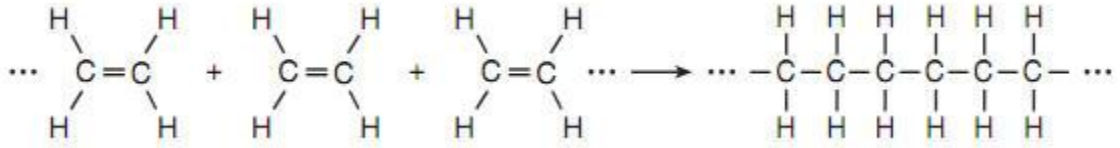
$2HOCH_2CH_2OH \rightarrow HOCH_2CH_2CH_2CH_2OH + HOH$

Monomers Dimer

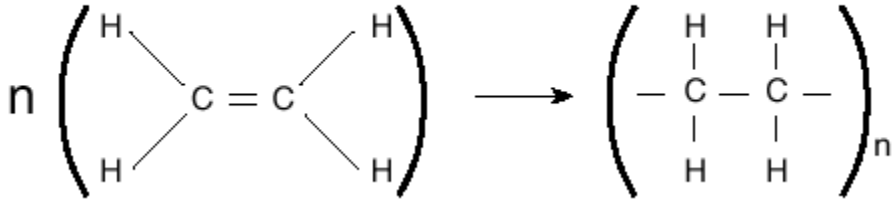
Dimer is 2 monomers combined
Trimer
Polymer
The prerequisite is 2 coupling groups on each end

3. Addition Polymerization

A double or triple bond is broken and a monomer adds to the chain

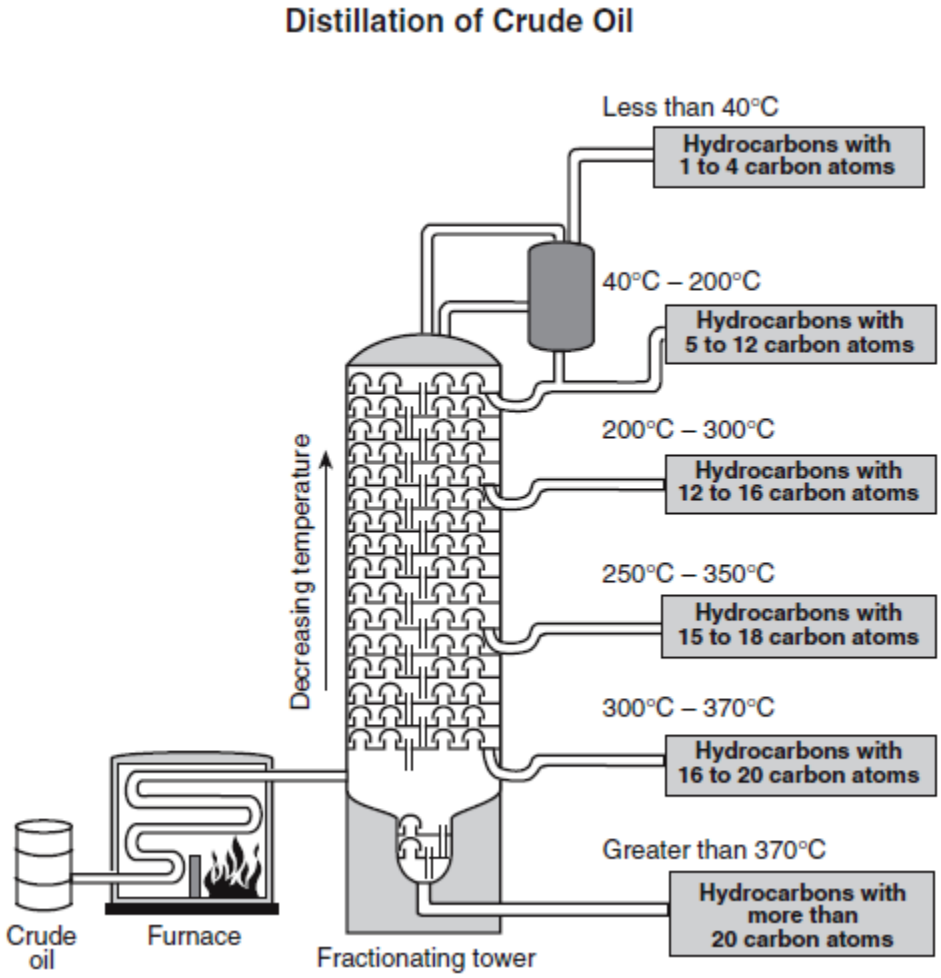


Note: n and n are very large numbers equal to about 2000.



H. Petroleum Reactions

1. Fractional Distillation- The various components of crude oil have different sizes, weights and boiling temperatures; so, the first step is to separate these components. Because they have different boiling temperatures, they can be separated easily by a process called fractional distillation.



2.Cracking-Large hydrocarbon are broken into smaller ones, yielding more valuable fractions (gasoline, fuel oils) using a catalyst.

$$C_{15}H_{32} \longrightarrow 2C_2H_4 + C_3H_6 + C_8H_{18}$$

ethene propene octane