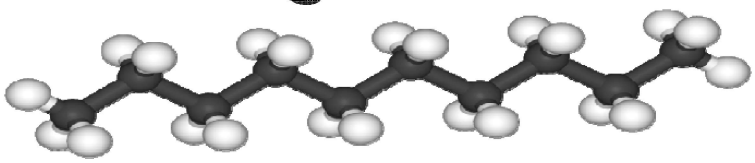
M6 Organic Chemistry

Due Date: January 19th

Name:

Class #:

Unit 11 - Organic Chemistry



Unit Vocabulary:

- Addition rxn
- Alcohol
- Aldehyde
- Alkane
- Alkene
- Alkyne
- Amide
- Amine
- Amino acid
- Dehydration synthesis
- Ester
- Esterification
- Ether
- Fermentation
- Functional group
- Halide (halocarbon)
- Hydrocarbon
- Isomer
- Ketone
- Monomer
- Organic acid
- Organic chemistry
- Polymer
- Polymerization
- Primary
- Saponification
- Saturated hydrocarbon
- Secondary
- Substitution rxn
- Tertiary
- Unsaturated hydrocarbon

Unit Objectives:

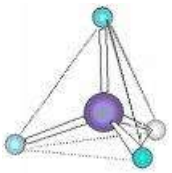
- Identify organic compounds versus inorganic compounds based on structure, name, or characteristics of an unknown compound
- Recognize the characteristics of organic compounds
- Differentiate between aliphatic, aromatic, saturated, and unsaturated compounds
- Name organic compounds based on IUPAC rules, with the help of table P and Q
- Draw organic compounds from a IUPAC name
- Distinguish between alkynes, alkenes, and alkanes
- Name and identify isomers
- Identify various functional groups of organic compounds using Table R:
    - Halide (halocarbon)
    - Alcohol
    - Ether
    - Aldehyde
    - Ketone
    - Organic Acid
    - Ester
    - Amine
    - Amide
- Categorize various organic reactions properly including addition, substitution, polymerization, esterification, fermentation, saponification, and combustion.

Organic Chemistry: the study of compounds that contain _____ and _____

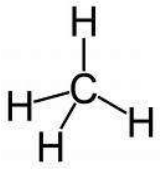
I. Why is carbon so special?

A. Carbon has _____ →  **or** 

B. These four single bonds spread out evenly to create a _____ molecule (like a tripod)



109.5 degrees, 3-D



(on paper, 2-D)

C. Carbon atoms _____ with other carbon atoms, forming _____, _____, and _____

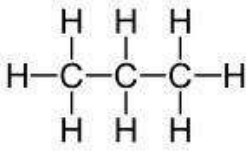
D. Two adjacent carbon atoms can share up to _____

E. Each shared pair of electrons is represented by a _____

II. HYDROCARBONS – organic molecules that contain ***only*** _____ & _____

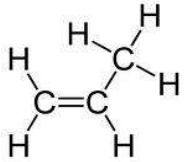
A. SATURATED Hydrocarbons - all _____ between carbons

1. _____ number of _____ attached (the same way a saturated solution holds the maximum amount of solute)
2. Single dash line (_____)→ _____
   - _____/_____ make up bonds (_____)

Example: 

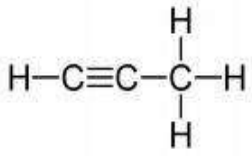
B. UNSATURATED Hydrocarbons - at least one _____ in carbon chain

1. Two dash lines (_____)→ _____
   - _____/_____ make up bonds (_____)

Example: 

2. Three dash lines (_____)→ _____
   - _____/_____ make up bonds (_____)

Example:



III. Properties of Organic Compounds

A. Bonding: _____ → _____ + _____

B. Solubility: most are _____ in water (generally _____)
   *_____

C. Conductivity: mostly _____ (s), (ℓ), & (aq) states
   *Only _____ in solution = _____

D. Melting/boiling points: _____ → _____

E. Reactivity Rate: _____; covalent molecules tend to have relatively _____ → _____ in reaction → rxn takes longer

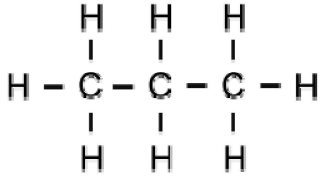
IV. Types Of Chemical Formulas

A. **Molecular Formula:** shows the _____ of each _____ in a compound; least informative formula

   Ex: Propane = C_3H_8

B. **Structural Formula:** shows the _____ of each _____ AND the _____ of the _____; most informative formula

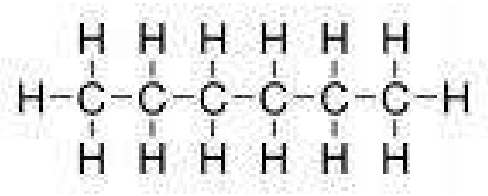
   Ex: Propane =



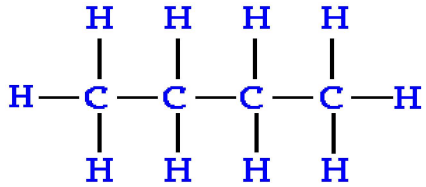
C. **Condensed Formula** = _____ of both _____ and _____ formulas; each carbon is written with its constituent hydrogens followed by the proper subscript

   Ex: Propane = $CH_3CH_2CH_3$

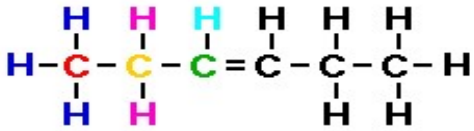
Open-Chained (Aliphatic)



Molecular formula	
Condensed formula	

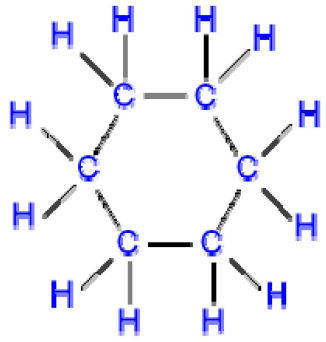


Molecular formula	
Condensed formula	



Molecular formula	
Condensed formula	

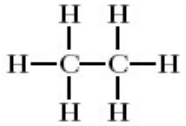
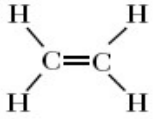
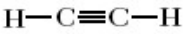
Closed-Chained (Aromatic)



Molecular formula	

*When drawing organic compounds you <u>MUST</u> always have $8e^-$ around each atom!
** EXCEPTION: Hydrogen (H) achieves its "octet" with only $2e^-$ around it.

Table Q
Homologous Series of Hydrocarbons

Name	General Formula	Examples	
		Name	Structural Formula
alkanes	C_nH_{2n+2}	ethane	
alkenes	C_nH_{2n}	ethene	
alkynes	C_nH_{2n-2}	ethyne	

n = number of carbon atoms

HOMOLOGOUS SERIES: a group of _____ in which each member differs from the one before it by _____

Note (above): there are always 4 bonds (8 electrons) around carbon & H can only have one bond around it (2 electrons)

Table P
Organic Prefixes

Prefix	Number of Carbon Atoms
meth-	1
eth-	2
prop-	3
but-	4
pent-	5
hex-	6
hept-	7
oct-	8
non-	9
dec-	10

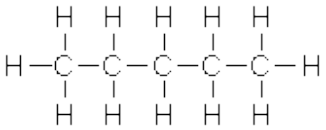
Examples: Convert the following using Tables P & Q

1) C_3H_8 _____
2) propyne _____
3) C_4H_8 _____
4) pentene _____
5) C_6H_{10} _____
6) hexane _____

Alkanes: The Saturated Aliphatics

- used as burning _____ (propane, butane, etc); _____ when burned; store a great deal of energy
- end in _____
- _____ → hydrocarbons with _____; have the maximum number of hydrogens bonded to their carbon chains
- General formula of _____; more than 2x as many hydrogens as carbons

Ex: pentane 5 carbons (n = 5 = pent) C_nH_{2n+2} = $C_5H_{2(5)+2}$ = C_5H_{12}

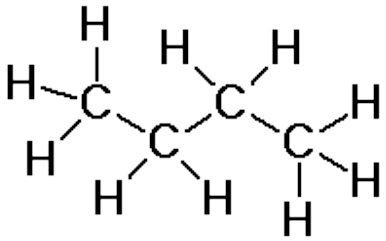


Straight Chain Alkanes:

*also referred to as n-alkanes ("normal" alkanes); example = n-hexane

General Rule for Naming Straight Chain Alkanes → use prefix (Table P) to tell you how many carbon atoms you have then add the suffix "-ane"

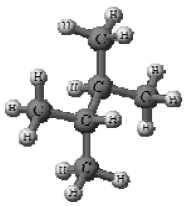
Both butane!

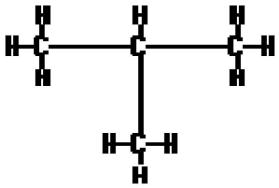


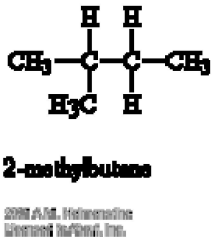
Branched Alkanes

Branched = not a straight continuous chain; organic molecule that has smaller branches coming off a longer continuous chain

*How can you tell if it's "branched"? You can't run your finger along all the carbons in one "sweep" (you hit dead-ends and have to turn around and retrace part/some of your path); because of this we must establish a "parent chain" or main backbone in order to name the molecule

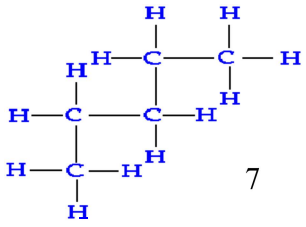






WARNING! Some molecules may appear to be branched, but are not…

For example:



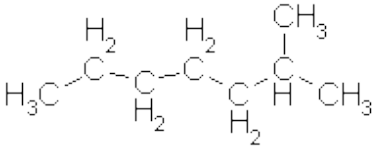
Naming Branched Alkanes

1) Locate the **longest possible carbon chain** (parent chain) in molecule. Any carbons coming off this chain are the **branches**. **Number the carbons** in the parent chain so that the branch(es) fall at the **lowest possible number/sum**
2) Name the **branches first** (separately, in alphabetical order as per their prefix) along with the **# of the C they are on**.

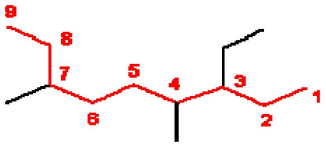
prefix based on the # C's (table P) + suffix –yl

3) Branches are named separately unless there are two of the same. If this is the case, lump them into the same branch name (w/ number locations) & add appropriate **prefix** (di, tri, tetra, etc.) depending on how many C's in branch.
4) The **parent chain** is **stated last** in the name (the # carbons in parent chain should agree with the prefix in the last word of the chemical name).

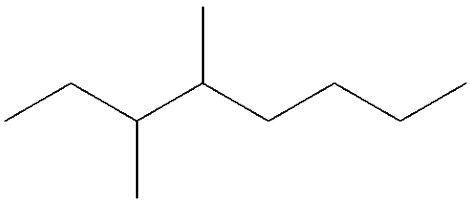
Example 1:



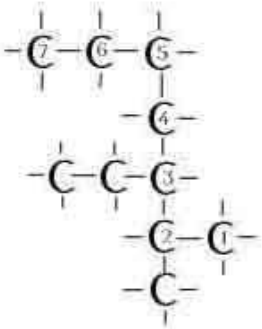
Example 2:



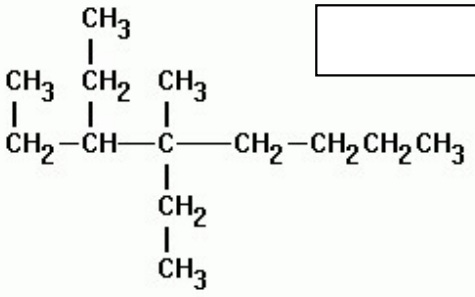
Example 3:



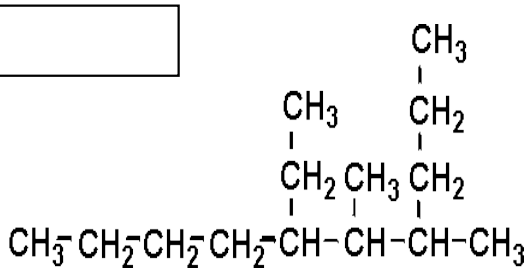
Example 4:



Example 5:



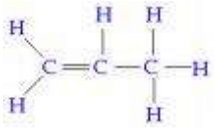
Example 6:



Unsaturated Aliphatics - Alkenes

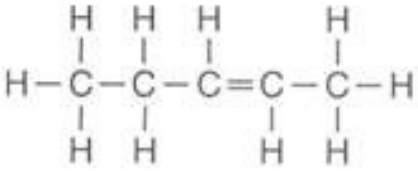
- hydrocarbons with a DOUBLE BOND (which makes it unsaturated)
- General formula = C_nH_{2n}; always twice as many hydrogens as carbons in formula
- End in –ene
- n-alkene (the "n" tells you what carbon # the double bond is located at within the molecule; use "n" only if molecule has more than 3C's)

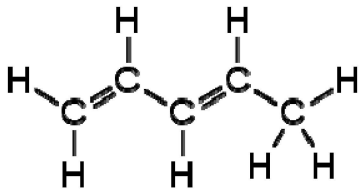
Ex: propene → _____



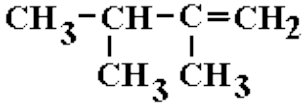
NOTE: you only need to include a number (for the multiple bond location) if there is more than one location that it could potentially be at

STRAIGHT CHAIN ALKENES - number the lowest # carbon where the double bond is located, then add the suffix "-ene" to the name (prefix should refer to the number of C's)





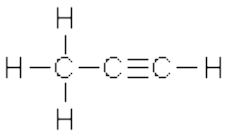
BRANCHED ALKENES - branch prefix comes 1st in name; parent chain comes last in name along with the # of where the double bond is located

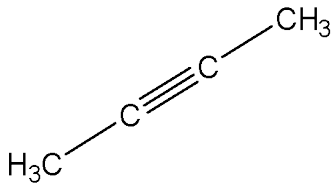


Unsaturated Aliphatics - Alkynes

- hydrocarbons with a TRIPLE BOND (makes them unsaturated)
- General Formula C_nH_{2n-2}; less than 2x as many hydrogens as carbons
- End in –yne
- n-alkyne (the "n" tells you where the triple bond is located at within the molecule); use "n" only if molecule has more than 3C's

Ex:

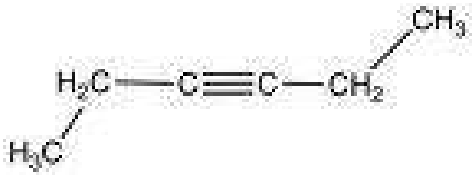




NOTE: You only need to include a number (for the multiple bond location) if there is more than one possible location.

STRAIGHT CHAIN ALKYNES – state the lowest carbon # where the triple bond is located then add the suffix "-yne"

Example 1:



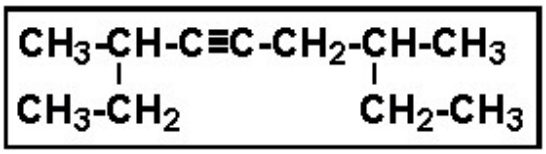
Example 2:

Example 3: 2-pentyne

BRANCHED ALKYNES - branch prefix comes 1st in name; parent chain comes last in name along with the # of where the double bond is located

Example 1: 2-methyl 3-pentyne

Example 2:



Example 3: 3-methyl 1-butyne

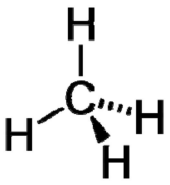
Example 4:

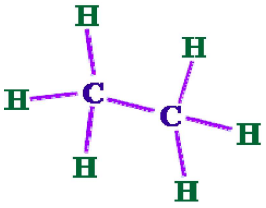
4-methyl 2-hexyne

Example 5: 2,3-dimethyl 5-heptyne

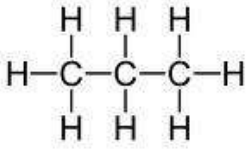
Isomers: Compounds that have the same molecular formula but have different structural formulas and different names; isomers have different chemical & physical properties; at least 4 carbons must be present in molecule to have potential isomers

Example: Methane, Ethane, Propane DO NOT have any isomers





Ethane

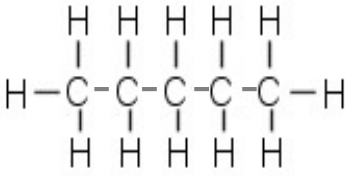


BUTANE is the first molecule to have isomers; the larger the molecule (the more carbon atoms) the more isomers the molecule will have

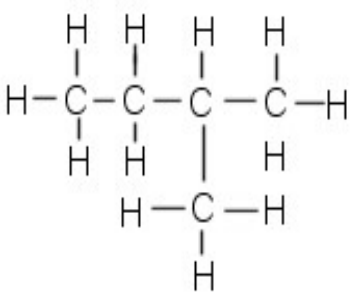
*There are only 3 ways to make an isomer:

1. _____
2. _____
3. _____ (a double or triple bond)

Ex 1: **Pentane** isomers - break off a terminal carbon and put it in a non-terminal position

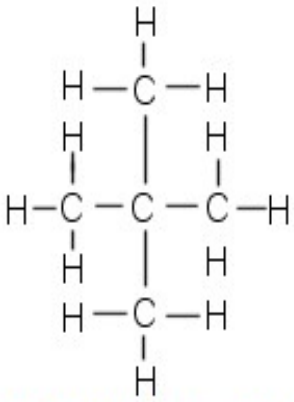


Pentane



2 methyl butane

- methyl group hangs off 2nd C atom
- longest chain is 4 C's long = butane



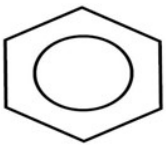
2,2 dimethyl propane

- 2 methyl groups both hang off 2nd C atom
- longest unbroken chain is 3 C's = propane

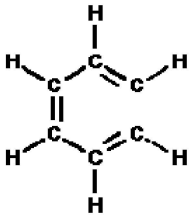
*Notice, you can only make branches on _____

Ex 2: **Pentene** isomers – ***either*** break off a terminal carbon and put it in a non-terminal position ***or*** move the double bond

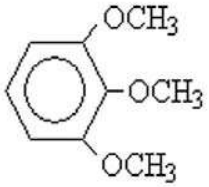
Aromatic Hydrocarbons = hydrocarbons that contain one or more benzene rings or closed chains in their structure (not on Regents exam)



benzene



benzene



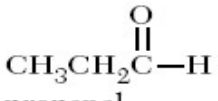
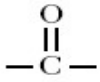
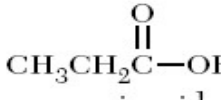
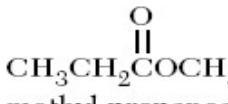
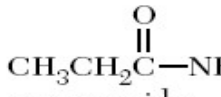
1,2,3 –trimethoxy benzene

Current Events → Benzene was the compound that was supposedly found present (controversial quantity) in Coca-Cola back in 2006 (it is a proven carcinogen which causes childhood leukemia)

FUNCTIONAL GROUPS = organic compounds that form when one or more hydrogens in a hydrocarbon are replaced; atom/group of atoms that give the organic compound certain characteristics/properties

Use the following table when YOU HAVE MORE THAN JUST A HYDROCARBON!

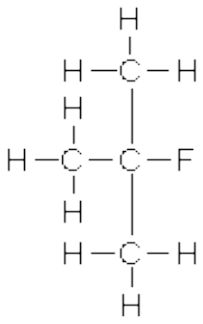
Table R
Organic Functional Groups

Class of Compound	Functional Group	General Formula	Example
halide (halocarbon)	—F (fluoro-) —Cl (chloro-) —Br (bromo-) —I (iodo-)	*R*—*X* (*X* represents any halogen)	$CH_3CHClCH_3$ 2-chloropropane
alcohol	—OH	*R*—OH	$CH_3CH_2CH_2OH$ 1-propanol
ether	—O—	*R*—O—*R′*	$CH_3OCH_2CH_3$ methyl ethyl ether
aldehyde			 propanal
ketone			 2-pentanone
organic acid			 propanoic acid
ester			 methyl propanoate
amine			$CH_3CH_2CH_2NH_2$ 1-propanamine
amide			 propanamide

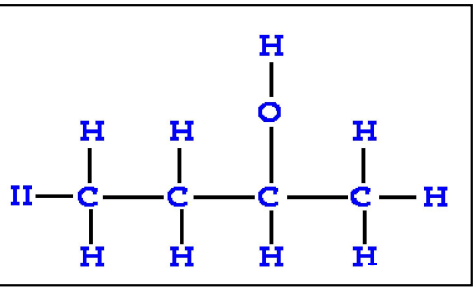
R represents a bonded atom or group of atoms.

1. **Halides (Halocarbon)=** one or more hydrogen atoms on a hydrocarbon is replaced by a HALOGEN (group 17 element such as F, Cl, Br, I)
   - Same rules as naming hydrocarbon branches except now you must state the location of the halogen along the carbon chain (lowest # location)
   - May also contain branches (same naming rules as before)

Examples:

		
2-chloropropane		2,2,3-trichlorobutane

2. **Alcohols** = one or more hydrogen atoms on a hydrocarbon is replaced by an –OH (hydroxyl) group
   - *"-e"* ending on hydrocarbon is replaced by *"-ol"*
   - Same rules as naming halogens, except now you must state the location of the hydroxyl along the carbon chain (lowest # location)
   - Alcohols (covalent molecules) are NOT BASES (ionic)
     - ✓ NONELECTROLYTES
     - ✓ POLAR & WATER SOLUBLE
   - CAUTION: organic acids also have an –OH in their functional group!

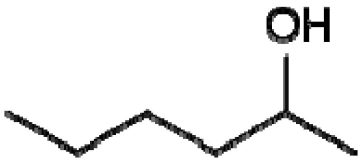
	
1-propanol (see Table R)	

Primary alcohol = -OH is located on a terminal carbon (carbon that's attached to **ONE** other carbon in chain)

Example: 1-pentanol

Secondary alcohol = -OH is attached to carbon that is attached to an interior carbon **TWO** other carbons in chain

Example:



Tertiary alcohol = -OH is attached to carbon which is attached to **THREE** other carbons

Example: 2-methyl-2-propanol

Dihydroxy alcohol = alcohol that has **TWO** -OH groups

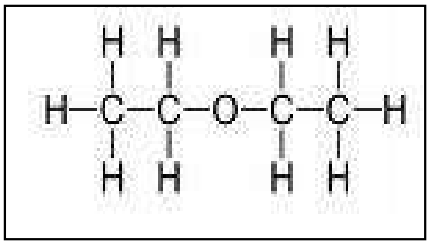
Example: 1,2-ethanediol

Trihydroxy alcohol = alcohol that has **THREE** OH's coming off the carbon chain

Example: 1,2,3-propanetriol

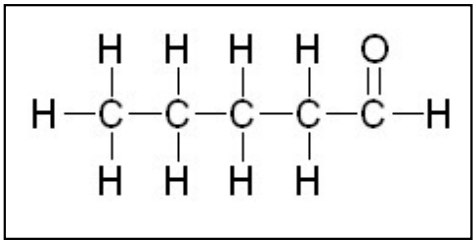
3. **Ethers** = look for -O- bridging two hydrocarbon chains
   - name two branches off the –O- (alphabetical if necessary) then add "ether" to the end of the name
   - if both branches are the same use "di (*insert type of branch*) ether"
   - NEVER USE #'S in name since there are only 2 sides to the O!

   Examples:

		
methyl ethyl ether		butyl propyl ether

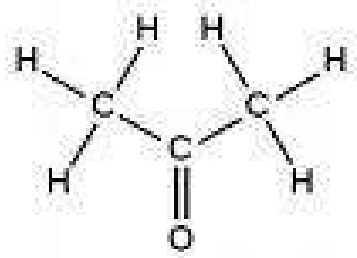
4. **Aldehydes** = carbonyl group (-C=O) found at END of hydrocarbon chain
   - *"-e"* at end of alkane is replaced by *"-al"*
   - very similar to ketones – BEWARE!

   Examples:

	
Propanal (see Table R)	

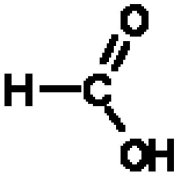
5. **Ketones** = carbonyl group (-C=O) located on an INTERIOR CARBON atom (within the chain)
   - *"-e"* at end of alkane replaced by *"-one"*
   - must cite the location of the –C=O in the carbon chain
   - often used as solvents
   - Very similar to aldehydes – BEWARE!

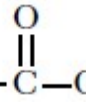
Examples:

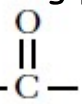
	
2-pentanone (see Table R)	

6. **Organic Acids** = carboxyl group —C(=O)—OH found at terminal carbon
   - Hydrocarbon ending *"-e"* replaced with *"-oic"* then add "acid" as second word in the name
   - Generate _____ in solution ==> _____

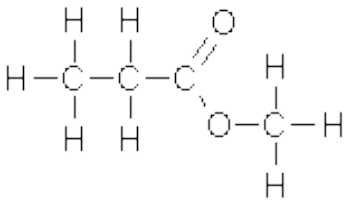
Examples:

	
propanoic acid (see Table R)	

7. **Esters** = contains  connecting parent chain to branch

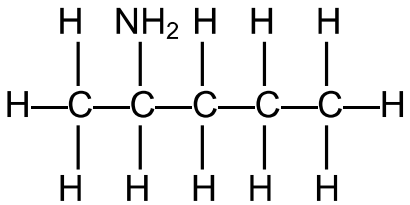
- hydrocarbon chain containing  is the parent chain
  - ✓ replace the "-e" at the end of the name with "-oate."
- hydrocarbon chain single-bonded to oxygen is the branch
  - ✓ name as you would any other branch
- known by their strong fragrant aromas (ex: wintergreen)

Examples:

		
ethyl butanoate		propyl methanoate

8. **Amines** = "N" alone (w/ only H's) seen within the carbon chain
   - Amine group can be a branch off the parent chain (like a methyl branch)
     - ✓ Number the carbon with the amine group, name the parent chain, replace the "-e" at the end of the name with "-amine."
   - Amine group can be "buried" within the carbon chain
     - ✓ Name exactly the same as you would an ether, except substitute the word "amine" for "ether." (See Table R)

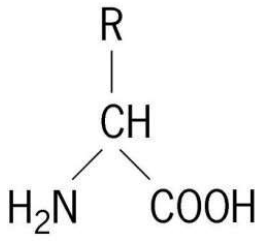
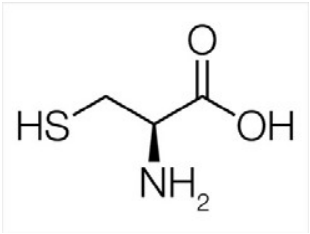
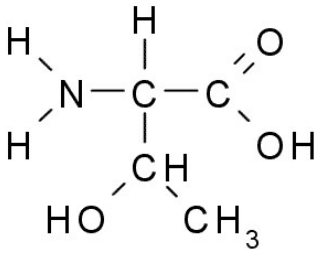
Examples:

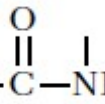
		
1-propanamine		ethyl methylamine

✳ **Amino Acids** = organic molecules containing both a carboxyl and an amine group

- ✓ don't worry about naming these, just recognize them
- ✓ can also contain additional functional groups

Ex: Box the functional groups in the examples below:

General Formula	Cysteine	Threonine
		

9. **Amides** = contains  group; can be at the terminal position or connecting a parent chain to a branch

Examples: (terminal position)

propanamide (see Table R)	butanamide

Examples: (connecting parent chain to branch)

methyl ethanamide	ethyl propanamide

ORGANIC REACTIONS:

1. **Combustion (AKA Oxidation)** = a HYDROCARBON (alkane, alkene, or alkyne) is ***burned*** in the presence of OXYGEN (O_2 is a reactant) to produce water and CO_2. ***Must know this reaction cold!***

Ex: _____ + _____ → _____ + _____

_____ + _____ → _____ + _____

2. **Substitution** = 1+ HYDROGEN atoms in a saturated alkane REPLACED/substituted by another atom/group

Ex: _____ + _____ → _____ + _____

_____ + _____ → _____ + _____

3. **Addition** = atoms/groups are added at the multiple (double or triple) bond ofan unsaturated hydrocarbon to become a saturated halocarbon (halide); 2 reactants turn into ONE LARGER PRODUCT

Ex: _____ + _____ → _____

_____ + _____ → _____

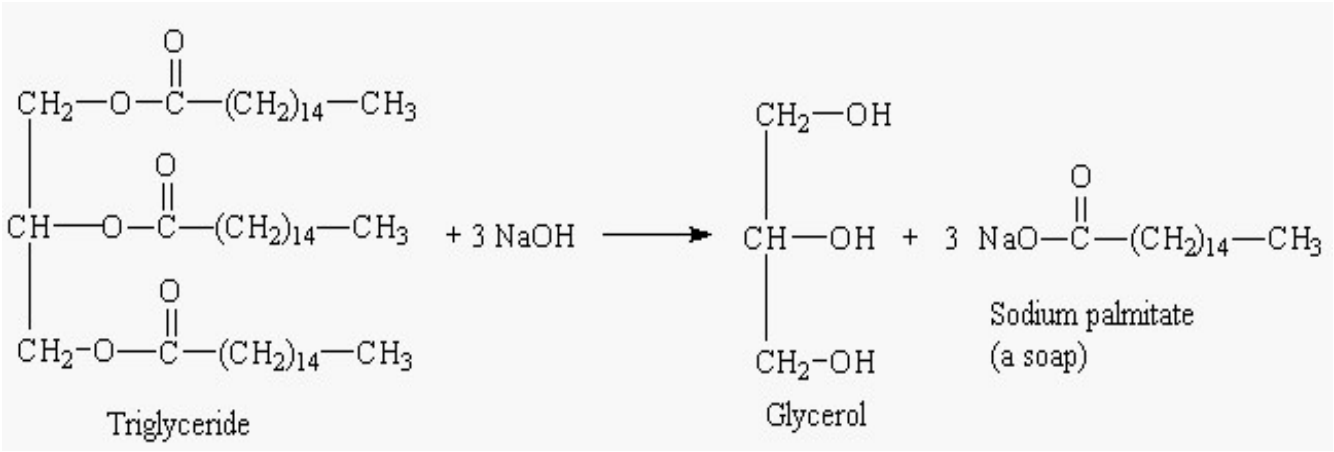
4. **Esterification** = an ester is created, putting an alcohol and acid together by means of dehydration polymerization → PRODUCES AN ESTER AND WATER.

Ex: _____ + _____ → _____ + _____

_____ + _____ → _____ + _____

5. **Saponification** = making SOAP. Ester is always on left side; ester reacts with inorganic base to produce alcohol (glycerol) and soap; producing soap and glycerol from a fat and a strong base

_____ + _____ → _____ + _____



- must use Table R to identify these!
- Reaction is VERY COMPLICATED looking

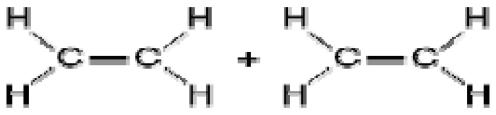
6. **Fermentation** = the production of alcohol and CO_2 from a sugar. In this specific case, yeast contains an ENZYME that breaks GLUCOSE into CO_2 an ETHANOL; ***Must know the example cold!***

Ex: _____ → _____ + _____

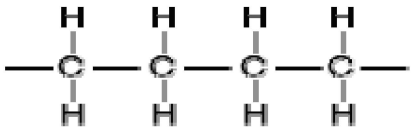
_____ → _____ + _____

7. **Polymerization** = FORMATION OF LARGE MOLECULES called polymers (organic compounds made up of chains of smaller units covalently bonded together called monomers); SMALL MOLECULES (MONOMERS) JOIN TOGETHER to form a larger molecule (polymer). Polymers are large molecules with unique characteristics. Examples of natural polymers: starch, cellulose, protein. Examples of synthetic polymers: plastics, nylons, rayons, polyester

   - **Addition Polymerization** = unsaturated monomers join by breaking their double or triple bonds to bond with one another; makes long chains!



ethene + ethene



polythene

- **Condensation Polymerization** = monomers join by REMOVING H_2O; hydroxyl group (-OH) and ether/ester linkage join to create H_2O