ORGANIC CHEMISTRY

- **Organic Chemistry:** study of carbon and carbon compounds; there are a lot of carbon compounds. The C atoms bond together to form chains or rings.
- **Common Characteristics:**

1. Generally non-polar (won't dissolve in water)
2. Soluble in non-polar solvents
3. Non-electrolytes.
4. Low melting points
5. Reactions generally slower than inorganic compounds
6. Reactions have higher activations energies (therefore slower reactions)

- Carbon has 4 valence electrons and therefore can form 4 covalent bonds around them (remember single, double or triple)
- **Hydrocarbons:** contain carbon and hydrogen atoms.

Table P &Q: Table P indicates the prefix used based on the # of carbons.

ALKANE: (-ane)

- Hydrocarbons are made up of only **single bonds**, and are therefore considered **saturated.**

ALKENE: (-ene)

- Alkenes have one **double bond** and classified as **unsaturated.**

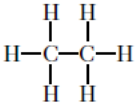
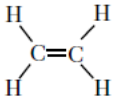
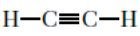
ALKYNE : (-yne)

- Alkynes have one **triple bond** and are considered **unsaturated.**

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

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	

Note: n = number of carbon atoms

- **Condensed Formulas:** Taking an organic compound, and shortening the chemical formula. Same compound, just written differently.

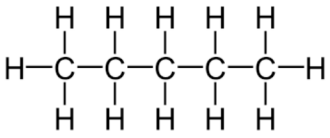
Alkyl Group: (-yl)

- Also hydrocarbons, known as side chains.
- Have one less hydrogen then a corresponding alkane.

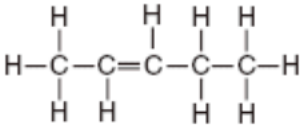
NUMBER OF CARBON ATOMS	STEM NAME	SIDE CHAIN (ALKYL GROUP) NAME	
1	meth	methyl	CH_3
2	eth	ethyl	C_2H_5
3	prop	propyl	C_3H_7
4	but	butyl	C_4H_9
5	pent	pentyl	C_5H_{11}
6	hex	hexyl	C_6H_{13}
7	hep	heptyl	C_7H_{15}
8	oct	octyl	C_8H_{17}
9	non	nonyl	C_9H_{19}
10	dec	decyl	$C_{10}H_{21}$

SUMMARY ON HOW TO DRAW CARBON COMPOUNDS:

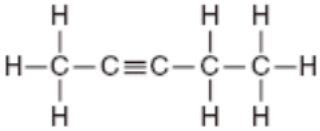
1. Look at the prefix (table P), which will tell you the number of carbons.
2. Put the bonds between the carbons (-ane = single bonds; -ene = double bond; and –yne means a triple bond)
3. The number before –ene and –yne tells you where the double or triple bond is after that carbon atom, Ex: 2-pentene (db after 2nd carbon), or 1-butyne (tb after 1st carbon).
4. When needed, if you have an alkyl group like methyl (CH_3), the number before tells you which carbon atom to put it on; Ex: 2-methyl (put the methyl on the 2nd carbon).
5. Put all of the appropriate hydrogen atoms around the carbon atoms if they belong there.



Pentane



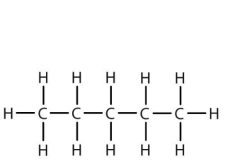
2-Pentene



2-Pentyne

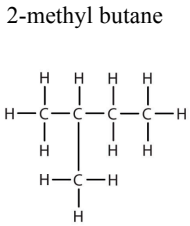
ISOMERS: compounds that have the same molecular formula but different structural formula.

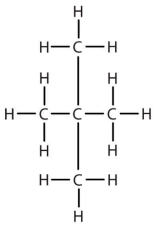
- The rule to naming these structures is to count the number of carbon atoms in the longest unbroken chain. You want to use the lowest possible number, so this means you might have to count from the left to right or from right to left.



Pentane

2-methyl butane





2,2 dimethyl propane

OTHER ORGANIC COMPOUNDS & FUNCTIONAL GROUPS (Table R):

Alcohols: (OH)

- The OH in an alcohol is a hydroxyl, and the OH^- in a base is a hydroxide ion; **ALCOHOLS ARE NOT BASES.**
- To name an alcohol, drop the –e from the corresponding alkane and all **–ol.**
- OH can be placed on any carbon and therefore a number is required to indicate on which carbon it's on when there are 3 or more carbons in a chain.
- Diol (2 OH are present); triol (3 OH are present)

Ether:

- You name this compound by using the word **–ether** at the end and use the name of the alkyl groups attached at both ends.
- Alcohols and Ethers make isomers of each other when there are the same number of carbons atoms.

Aldehyde: (CHO)

- Named by dropping the final –e in an alkane and adding **–al.**
- Found at the end, no number required.

Ketone:

- Ketones are named by dropping the final –e from the corresponding alkane and adding **–one.**
- The double bonded oxygen MUST be on an inside carbon, and therefore, requires a number to indicate on which carbon it's attached to on the chain.
- Aldehydes and Ketones make isomers of each other when there are the same number of carbon atoms.

Organic Acids: (COOH)

- Named by dropping the final -e from the corresponding alkane and adding **– oic acid.**
- Functional group at the end, and therefore, no number is required.

Halides: (F, Cl, Br, I)

- Name it by using a number to state which atom the halogen is being attached to, then use the prefix for that halogen (fluoro-, chloro-, bromo-, iodo-) and end with the appropriate alkane.
- There can be multiple halides so it's necessary to use a number to indicate which carbon(s) they are on. Use prefixes like di, tri, etc … if there are more than one of the same kind of halogen.

Amine:

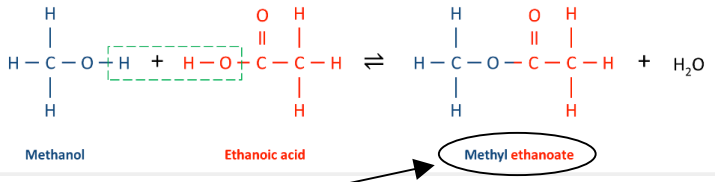
- Named by dropping the final –e in the hydrocarbon and adding **–amine.**
- Can be placed on any carbon, so a number is required.

Amide:

- Named by dropping the final –e in the hydrocarbon and adding **–amide.**
- Functional group at the end, therefore no number is required.

Ester: (COO)

- Esterfication – Alcohol + Acid → Ester + Water



- How to name:
  1. Name the part that came from the alcohol first using an alkyl name depending on how many carbon atoms there were.
  2. Name the part that came from the acid second by naming it like an alkane depending on the number of carbons, dropping the –ane, and adding the ending –oate.

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	$-\overset{O}{\overset{\|\|}{C}}-H$	$R-\overset{O}{\overset{\|\|}{C}}-H$	$CH_3CH_2\overset{O}{\overset{\|\|}{C}}-H$ propanal
ketone	$-\overset{O}{\overset{\|\|}{C}}-$	$R-\overset{O}{\overset{\|\|}{C}}-R'$	$CH_3\overset{O}{\overset{\|\|}{C}}CH_2CH_2CH_3$ 2-pentanone
organic acid	$-\overset{O}{\overset{\|\|}{C}}-OH$	$R-\overset{O}{\overset{\|\|}{C}}-OH$	$CH_3CH_2\overset{O}{\overset{\|\|}{C}}-OH$ propanoic acid
ester	$-\overset{O}{\overset{\|\|}{C}}-O-$	$R-\overset{O}{\overset{\|\|}{C}}-O-R'$	$CH_3CH_2\overset{O}{\overset{\|\|}{C}}OCH_3$ methyl propanoate
amine	$-\overset{\|}{N}-$	$R-\overset{R'}{\overset{\|}{N}}-R''$	$CH_3CH_2CH_2NH_2$ 1-propanamine
amide	$-\overset{O}{\overset{\|\|}{C}}-\overset{\|}{N}H$	$R-\overset{O}{\overset{\|\|}{C}}-\overset{R'}{\overset{\|}{N}}H$	$CH_3CH_2\overset{O}{\overset{\|\|}{C}}-NH_2$ propanamide

Note: *R* represents a bonded atom or group of atoms.

Effects of Functional Groups on Boiling Point

1.Alcohols and Acids: Have the highest BP because they are held together with hydrogen bonding.

2.All other functional groups: Next highest BP.

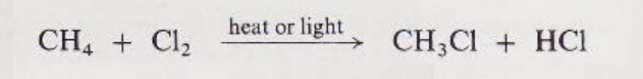
3.Hydrocarbons: Weakest BP.

Examples: Methanol → Methanal → Methane (highest to lowest BP)

ORGANIC REACTIONS:

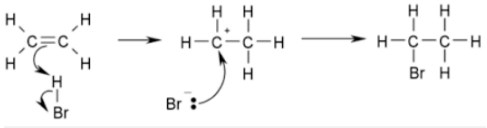
Substitution: Occurs in **ALKANES** only.

- 2 reactants and 2 products.



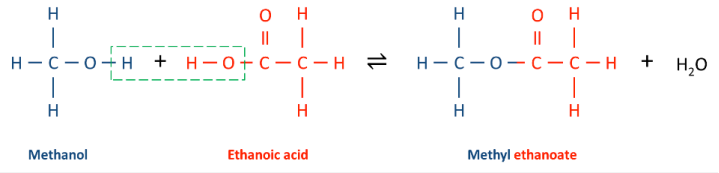
Addition: Happen only to **ALKENES & ALKYNES.** Breaking a double to a single or a triple to a double.

- 2 reactants and 1 product.



Fermentation: Glucose is broken down into **ethanol and carbon dioxide** (Anaerobic Respiration).

Esterfication: Alcohol + Acid → Ester + Water



Saponification: Reverse of esterification. This process produces SOAP.

Combustion: First 6 reactions on Table I.

- Organic Compound + O_2 → CO_2 + H_2O

Table I
Heats of Reaction at 101.3 kPa and 298 K

Reaction	ΔH (kJ)*
$CH_4(g) + 2O_2(g) \longrightarrow CO_2(g) + 2H_2O(\ell)$	−890.4
$C_3H_8(g) + 5O_2(g) \longrightarrow 3CO_2(g) + 4H_2O(\ell)$	−2219.2
$2C_8H_{18}(\ell) + 25O_2(g) \longrightarrow 16CO_2(g) + 18H_2O(\ell)$	−10943
$2CH_3OH(\ell) + 3O_2(g) \longrightarrow 2CO_2(g) + 4H_2O(\ell)$	−1452
$C_2H_5OH(\ell) + 3O_2(g) \longrightarrow 2CO_2(g) + 3H_2O(\ell)$	−1367

Polymerization: involves smaller molecules joining together to form one big molecule. A **polymer** is a large molecule made up of multiple monomers.

- **condensation:** polymerization by dehydration synthesis (removing water) to form a polymer. Ex: nylons, polyester. Naturally occurring polymers include starches and protein.
- **addition:** polymerization joining together by breaking a double or triple bond.

Name _____ Chap. 8 Organic Review Constructed Response

Base your answers to questions **1** and **2** on the information below and on your knowledge of chemistry.

Natural gas and coal are two fuels burned to produce energy. Natural gas consists of approximately 80% methane, 10% ethane, 4% propane, 2% butane, and other components.

The burning of coal usually produces sulfur dioxide, $SO_2(g)$ and sulfur trioxide, $SO_3(g)$, which are major air pollutants. Both $SO_2(g)$ and $SO_3(g)$ react with water in the air to form acids.

1. Draw a structural formula for the hydrocarbon that is approximately 2% of natural gas.

2. Write the general formula for the homologous series that includes the components of the natural gas listed in this passage.

---

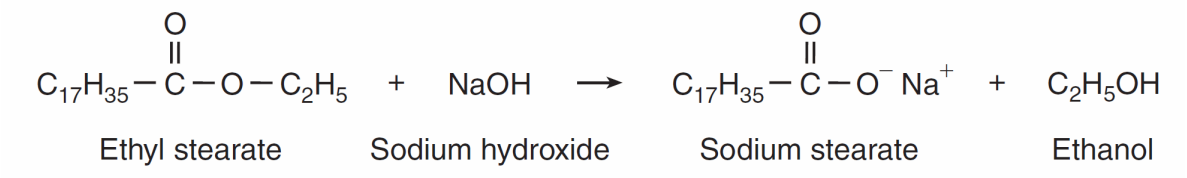
3. Base your answer to the following question on the information below and on your knowledge of chemistry.

Ethane, C_2H_6, has a boiling point of $-89°C$ at standard pressure. Ethanol, C_2H_5OH, has a much higher boiling point than ethane at standard pressure. At STP, ethane is a gas and ethanol is a liquid.

Identify the class of organic compounds to which ethanol belongs.

Base your answers to questions **4** and **5** on information below.

One type of soap is produced when ethyl stearate and sodium hydroxide react. The soap produced by this reaction is called sodium stearate. The other product of the reaction is ethanol. This reaction is represented by the balanced equation below.



4. To which class of organic compounds does ethyl stearate belong?

5. Identify the type of organic reaction used to make soap.

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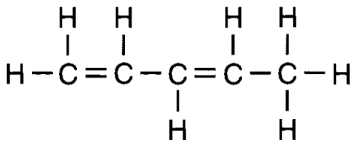
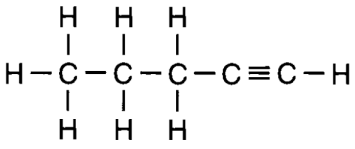
6. Two hydrocarbons that are isomers of each other are represented by the structural formulas and molecular formulas below.

Hydrocarbon 1



C_5H_8

Hydrocarbon 2

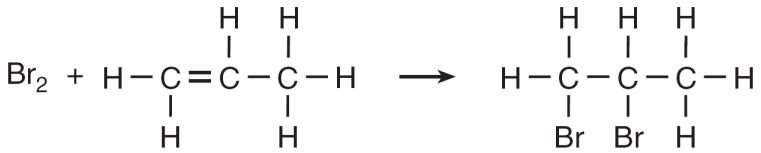


C_5H_8

Explain, in terms of structural formulas and molecular formulas, why these hydrocarbons are isomers of each other.

Base your answers to questions **7** and **8** on the information below.

A reaction between bromine and a hydrocarbon is represented by the balanced equation below.



7. Write the name of the homologous series to which the hydrocarbon belongs.

8. Identify the type of organic reaction.

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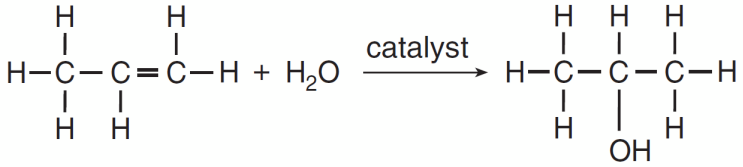
9. Base your answer to the following question on the information below.

In one industrial organic reaction, C_3H_6 reacts with water in the presence of a catalyst. This reaction is represented by the balanced equation below.



Explain, in terms of bonding, why C_3H_6 is classified as an unsaturated hydrocarbon.

10. Base your answer to the following question on the information below.

Biodiesel is an alternative fuel for vehicles that use petroleum diesel. Biodiesel is produced by reacting vegetable oil with CH_3OH. Methyl palmitate, $C_{15}H_{31}COOCH_3$, a compound found in biodiesel, is made from soybean oil. One reaction of methyl palmitate with oxygen is represented by the balanced equation below.

$$2C_{15}H_{31}COOCH_3 + 49O_2 \rightarrow 34CO_2 + 34H_2O + \text{energy}$$

Identify the type of organic reaction represented by the balanced equation.

11. Base your answer to the following question on the information below.

Gasoline is a mixture composed primarily of hydrocarbons such as isooctane, which is also known as 2,2,4-trimethylpentane.

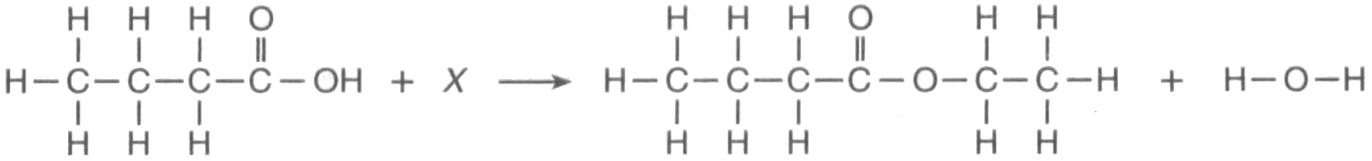
Gasoline is assigned a number called an octane rating. Gasoline with an octane rating of 87 performs the same as a mixture that consists of 87% isooctane and 13% heptane.

An alternative fuel, E-85, can be used in some automobiles. This fuel is a mixture of 85% ethanol and 15% gasoline.

In the space below, draw a structural formula for a molecule of 2,2,4-trimethylpentane.

Base your answers to questions **12** and **13** on the following information.

The equation below represents the reaction between butanoic acid and an unidentified reactant, *X*.



12. Draw a structural formula for the unidentified reactant, *X,* in the equation.

13. Identify the type of organic reaction represented by the equation.

Base your answers to questions **14** and **15** on the information below.

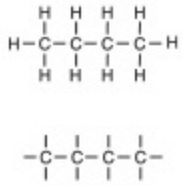
Given the balanced equation for an organic reaction between butane and chlorine that takes place at 300.ºC and 101.3 kilopascals:

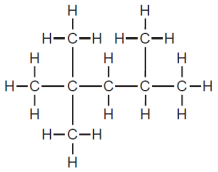
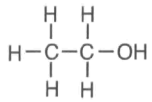
$C_4H_{10} + Cl_2 \rightarrow C_4H_9Cl + HCl$

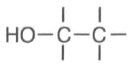
14. Draw a structural formula for the organic product.

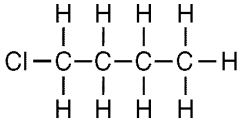
15. Identify the type of organic reaction shown.

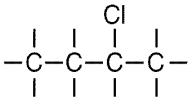
Answer Key
Organic Chemistry

1. 

2. C_nH_{2n+2}
3. –alcohol –alcohols –primary alcohol –monohydroxy alcohols
4. ester *or* esters
5. saponification
6. The molecular formulas of the two hydrocarbons are the same, but the structural formulas are different.
7. – alkene *or alkenes.*
8. – addition – halogenation – bromination
9. Acceptable responses include, but are not limited to: The C_3H_6 is unsaturated because each molecule has a double covalent bond between two of its carbon atoms. There is a carbon-carbon double bond in each molecule
10. Example: combustion
11. 
12. 



13. *Examples:* – esterification – dehydration synthesis
14. 



15. *Examples*: – substitution – chlorination – halogenation