

UNIT IX: ORGANIC CHEMISTRY
(Chemistry 11)

I. Introduction to Carbon Compounds:

- There exists over 8 million carbon compounds, and over 500 000 new ones are synthesized each year.
- Carbon compounds are the most industrially prolific, present in everything from plastics, to pharmaceuticals, to makeup.
- Carbon compounds exist naturally in the Earth as coal, or deposits of decaying plants that have accumulated and undergone pressure buildup over the years.
- The vast amount of uses and chemical properties of carbon compounds warrants it to have a special branch in chemistry called ORGANIC CHEMISTRY.

II. Organic Compounds & its Classes:

- C atom has four electrons for bonding and can be covalently shared with 4 other atoms in a tetrahedral configuration. (very stable configuration).
- This stability allows for some carbon compounds to be of enormous lengths.
- Other C compounds can also form into C.

There are 2 classes of organic compounds:

- 1) **Hydrocarbons** – those compounds that contain only carbons and hydrogens.
- 2) **Hydrocarbon Derivatives** – where the H atoms are substituted with other compounds or atoms.

No matter what type of organic compound, all possess a CARBON BACKBONE. However, the backbone may be STRAIGHT or BRANCHED.

Whether the compound is a hydro-carbon or a derivative, there are two forms that it can take:

1) **Saturated:**

All carbon bonding sites are singly bonded.
Saturated compounds are stable; do not react readily.

2) **Unsaturated:**

There exists double or triple bonds along the carbon backbone.
Unsaturated compounds are more reactive because the double or triple bond can be broken apart.

III. Hydrocarbons- A Closer Look:

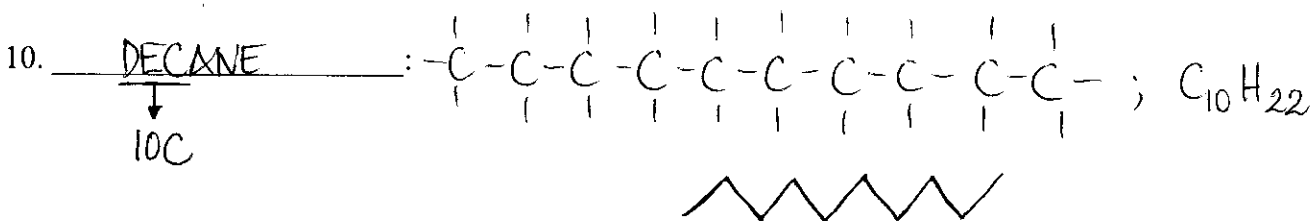
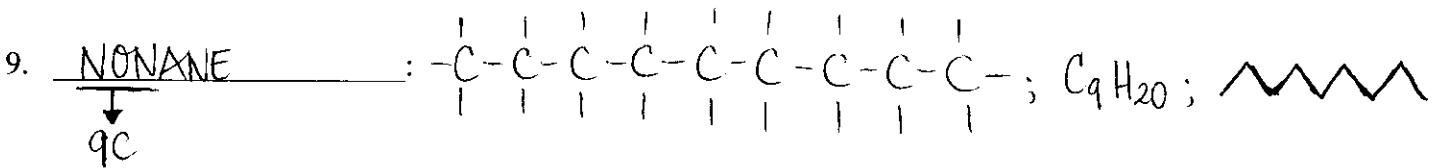
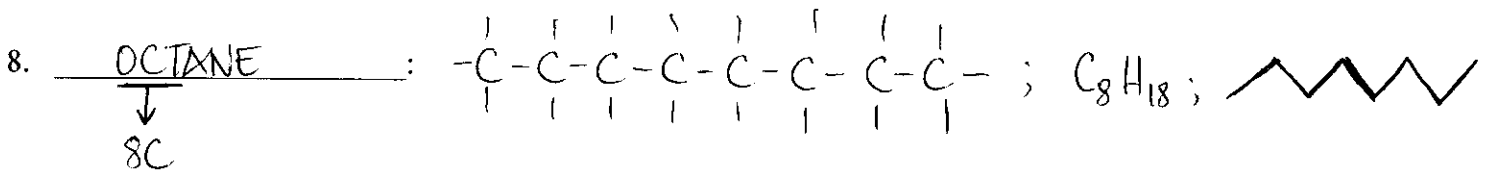
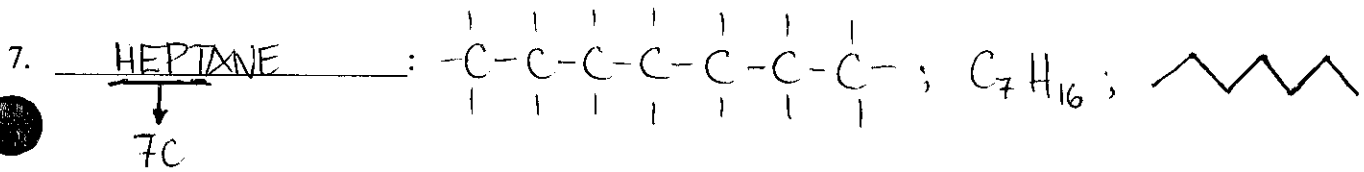
- There are 3 families of hydrocarbons: 1) ALKANES : singly bonded hydrocarbon
2) ALKENES : doubly bonded hydrocarbons
3) ALKYNES : triply bonded hydrocarbons.

A. Alkanes: (C_nH_{2n+2})

- May be straight or branched.
- Have relatively low boiling points due to the molecules' non-polarity.
As # of C increases, boiling point increases due to Van der Waals forces.

i) The First 10 Alkanes: (Straight Chains)

1. METHANE : *singly bonded.*
↓
1C
$$\begin{array}{c} \text{H} \\ | \\ \text{H}-\text{C}-\text{H} \\ | \\ \text{H} \end{array}; \text{CH}_4; \begin{array}{c} | \\ -\text{C}- \\ | \end{array}$$
2. ETHANE :
↓
2C
$$\begin{array}{c} \text{H} \quad \text{H} \\ | \quad | \\ \text{H}-\text{C}-\text{C}-\text{H} \\ | \quad | \\ \text{H} \quad \text{H} \end{array}; \text{C}_2\text{H}_6; \begin{array}{c} | \quad | \\ -\text{C}-\text{C}- \\ | \quad | \end{array}$$
3. PROPANE :
↓
3C
$$\begin{array}{c} \text{H} \quad \text{H} \quad \text{H} \\ | \quad | \quad | \\ \text{H}-\text{C}-\text{C}-\text{C}-\text{H} \\ | \quad | \quad | \\ \text{H} \quad \text{H} \quad \text{H} \end{array}; \text{C}_3\text{H}_8; \begin{array}{c} | \quad | \quad | \\ -\text{C}-\text{C}-\text{C}- \\ | \quad | \quad | \end{array}; \text{~}$$
4. BUTANE :
↓
4C
$$\begin{array}{c} \text{H} \quad \text{H} \quad \text{H} \quad \text{H} \\ | \quad | \quad | \quad | \\ \text{H}-\text{C}-\text{C}-\text{C}-\text{C}-\text{H} \\ | \quad | \quad | \quad | \\ \text{H} \quad \text{H} \quad \text{H} \quad \text{H} \end{array}; \text{C}_4\text{H}_{10}; \begin{array}{c} | \quad | \quad | \quad | \\ -\text{C}-\text{C}-\text{C}-\text{C}- \\ | \quad | \quad | \quad | \end{array}; \text{~}$$
5. PENTANE :
↓
5C
$$\begin{array}{c} | \quad | \quad | \quad | \quad | \\ -\text{C}-\text{C}-\text{C}-\text{C}-\text{C}- \\ | \quad | \quad | \quad | \quad | \end{array}; \text{C}_5\text{H}_{12}; \text{~}$$
6. HEXANE :
↓
6C
$$\begin{array}{c} | \quad | \quad | \quad | \quad | \quad | \\ -\text{C}-\text{C}-\text{C}-\text{C}-\text{C}-\text{C}- \\ | \quad | \quad | \quad | \quad | \quad | \end{array}; \text{C}_6\text{H}_{14}; \text{~}$$



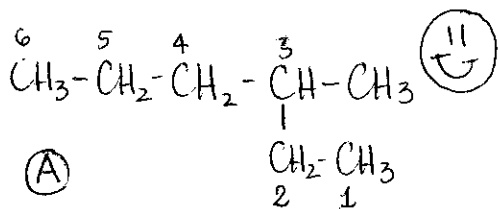
ii) Nomenclature: For Branched Alkanes

PREFIX - PARENT - SUFFIX

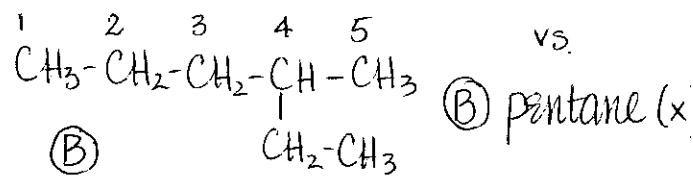
Where is the substituents? How many C? (backbone) What family?

—ane
—ene
—yne

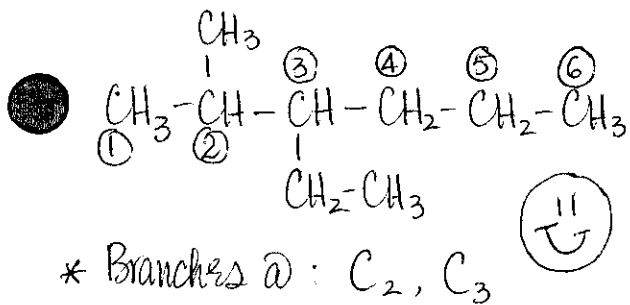
1. Find the longest continuous chain of C atoms present in the molecule. This is the PARENT name of the molecule.



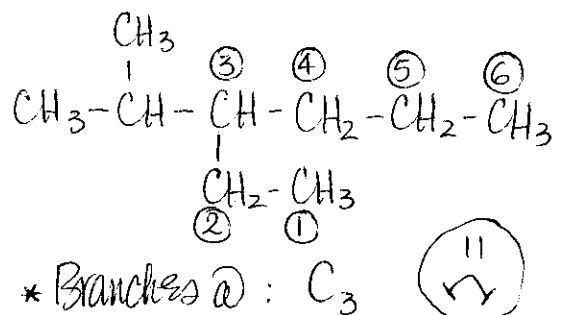
vs.



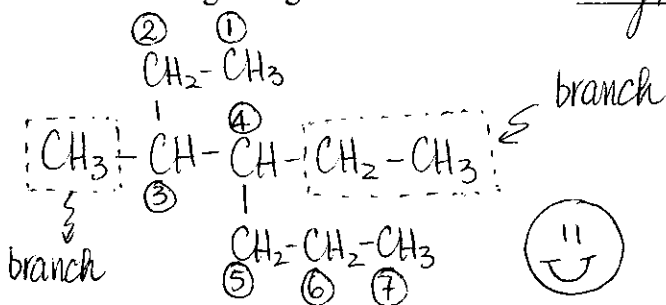
2. If 2 different chains of *equal lengths* are present, choose the one with the most number of branch points as the parent.



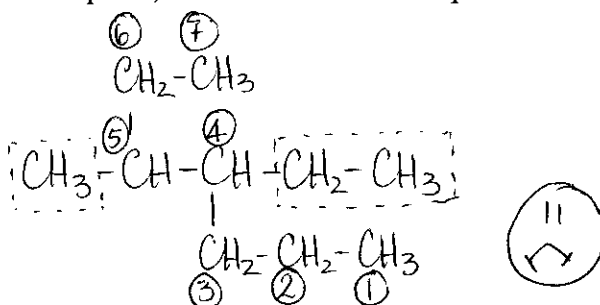
vs.



3. Beginning at the end nearer the first branch point, number each C in the parent chain.



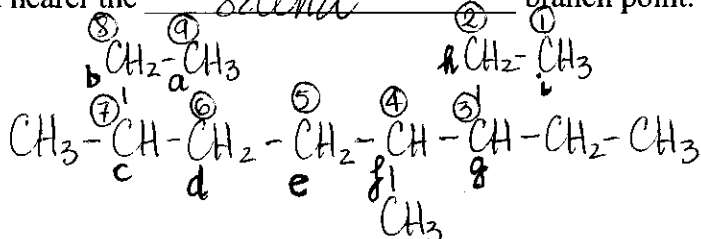
VS



* First Branch @ C₃

* First Branch @ C₄

4. If there is branching an *equal distance* away from both ends of the parent chain, begin numbering at the end nearer the second branch point.



★ The # method allows you to reach the branch sooner than the letter method

* Numbering Method:

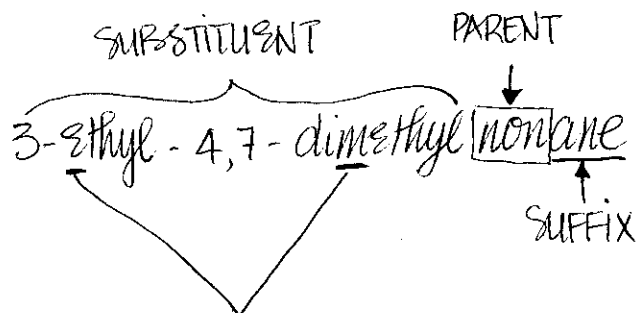
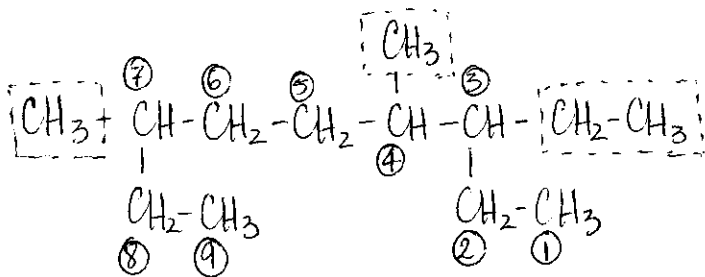


* Lettering Method:



5. Assign a name to each substituent/branch according to its point of attachment to the parent chain: Change the ending of the substituent to -yl.

Also assign the substituent with a number according to its placement on the # of the parent C.



* Branches @ C₃, C₄, C₇

* Name branches alphabetically.

B. Alkenes (C_nH_{2n})

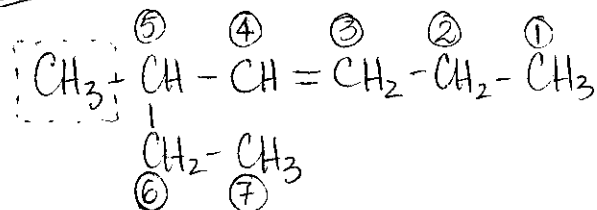
- There is at least 1 double bond along the carbon backbone (parent).
- Alkenes are more reactive because the site of the double bond can be broken to form a single bond.

Nomenclature:

The double bond gets top priority when naming alkenes. This means that the site of the double bond gets the lowest number possible. Aside from this, all other rules apply when naming alkenes.

SUFFIX: -----ene

Ex.



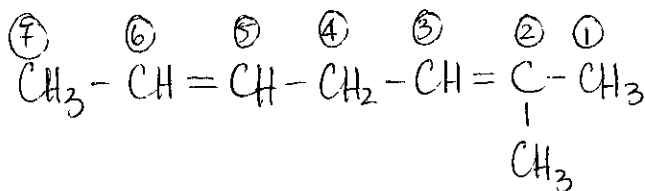
: 5-methyl-3-heptene

* where the double bond occurs.

OR

5-methyl hept-3-ene

Ex.

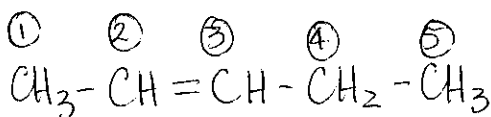


: 2,5 heptadiene

OR

hept-2,5-diene

Ex.



: * pent-2-ene

OR

2-pentene

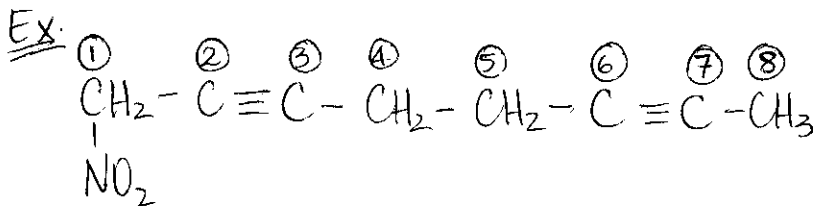
C. Alkynes (C_nH_n)

- There must be at least one triple bond in the backbone chain of an alkyne.
- Even more reactive than alkenes because the triple bond can be opened to form 3 single bonds.

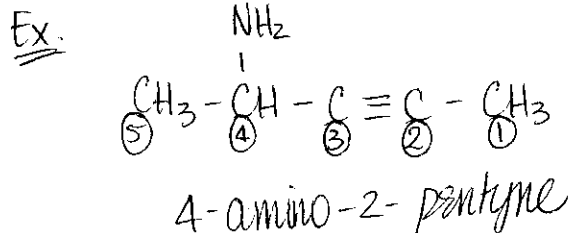
Nomenclature:

- The site of the triple bond gets top priority. This means that the triple bond site gets the lowest possible number.
- All other rules apply when naming alkynes.

SUFFIX: -----yne



1-nitro 3,6-octadiyne



4-amino-2-pentyne

* Other Common Substituents:

1) Halogens: bromo, chloro, etc.
(Br) (Cl)

2) AMINO: NH₂

3) NITRO: NO₂

IV. Functional Groups in Organic Compounds:

Functional Group: an identifying group on an organic compound that tells us which family a particular compound belongs to.

All organic compounds that belong in one family behave chemically similar.

There are 8 different functional groups: 1) ALCOHOL

2) ALDEHYDE

3) KETONES

4) CARBOXYLIC ACID

5) ESTERS

6) ETHER

7) AMINE

8) AMIDE

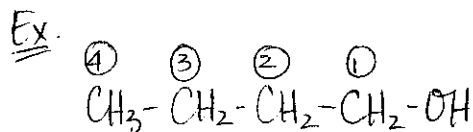
A. Alcohols:

Functional Group:



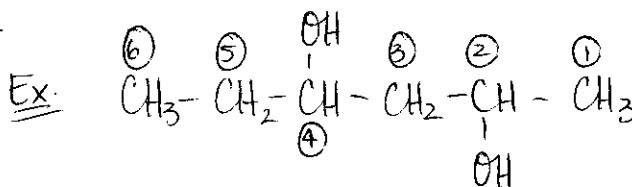
Nomenclature: (a) Numbering of the functional group takes top priority - It gets the lowest possible number.

(b) Suffix: -ol



* 1-butanol

* n-butanol



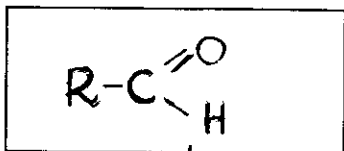
2,4-hexandiol

OR

hexan-2,4-diol

B. Aldehyde:

Functional Group:

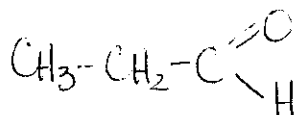


Nomenclature: (a) Functional group gets top priority.

(b) Suffix: -al

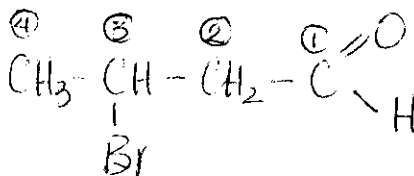
NOTE: The functional group is always on the extremest carbon (i.e. no # designatio. is needed).

Ex.



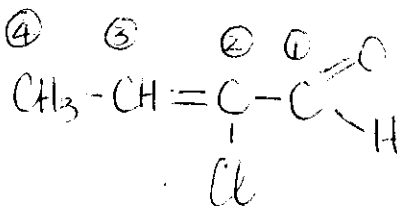
* propanal

Ex.



* 3-bromo-butanal

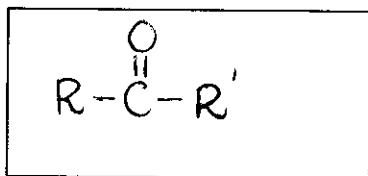
Ex.



* 2-chloro but-2-enal

C. Ketone:

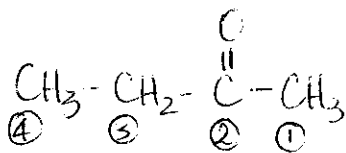
Functional Group:



Nomenclature: (a) Site of functional group gets first priority.

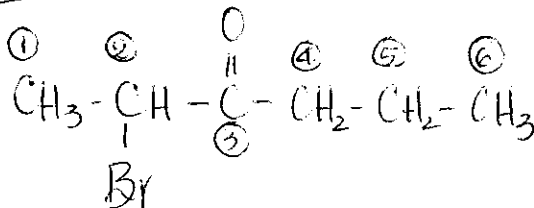
(b) Suffix: -one

Ex.



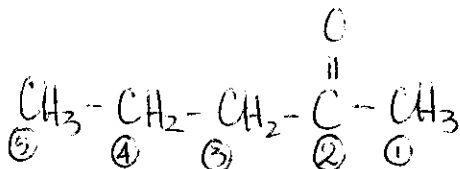
* 2-butanone

Ex.



* 2-bromo-3-hexanone

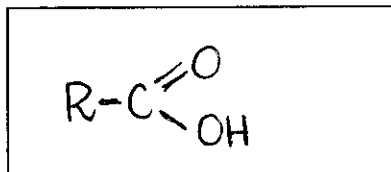
Ex.



2-pentanone

D. Carboxylic Acid:

Functional Group:

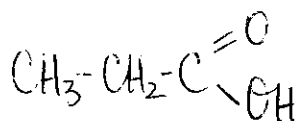


NOTE: The functional group
↳ always on the extremest
carbon. (No # designation
↳ needed).

Nomenclature: (a) Functional group gets top priority.

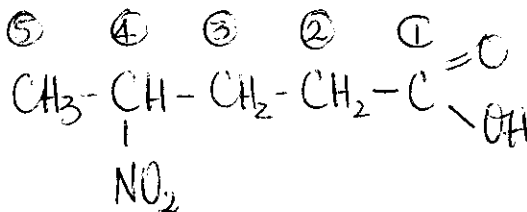
(b) Suffix: -oic acid

Ex.



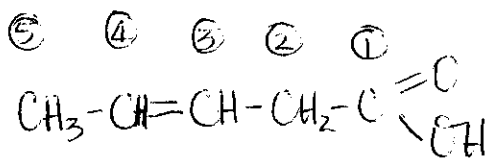
* propanoic acid

Ex.



* 4 nitro-pentanoic acid.

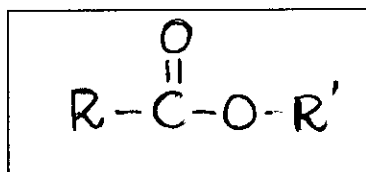
Ex.



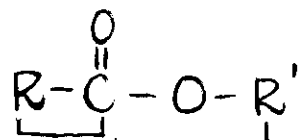
3-pentenoic acid

E. Ester:

Functional Group:



Nomenclature:

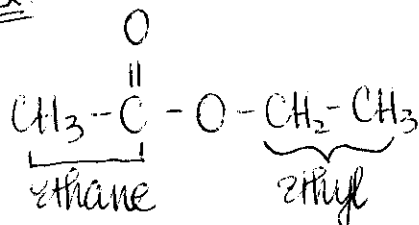


* Name 2nd
* Main chain

* Name first
* Treat as a branch

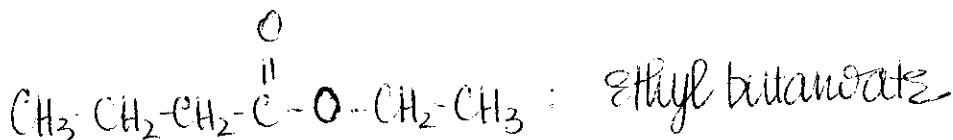
SUFFIX: -oate

Ex.



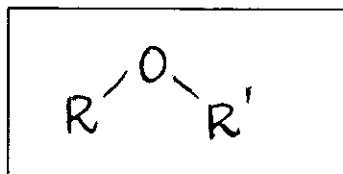
: ethyl ethanoate

Ex.



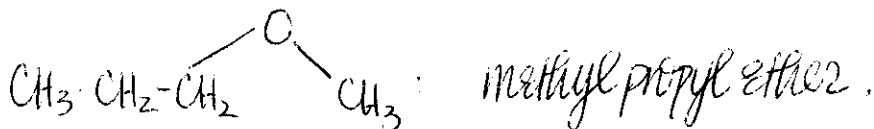
F. Ether:

Functional Group:

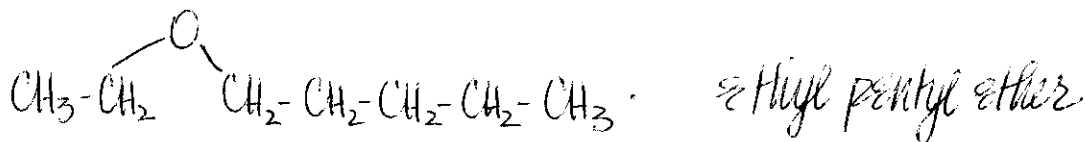


Nomenclature: (a) Name the two "arms" on either side of the oxygen alphabetically
 * Treat the 2 arms as branches - change ending to -yl.
 (b) Suffix: ether

Ex.

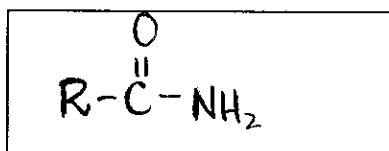


Ex.



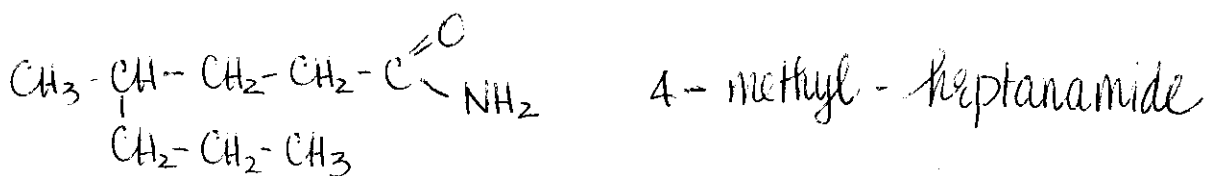
G. Amide:

Functional Group:

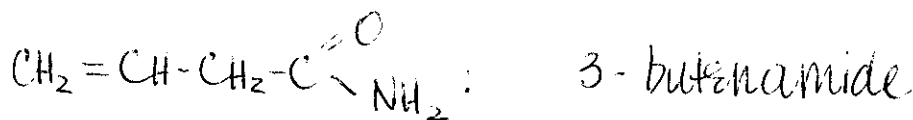


SUFFIX: - amide

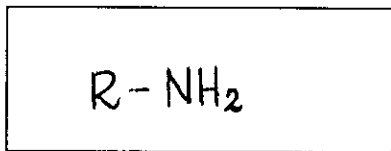
Ex.



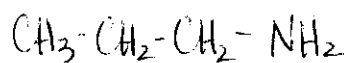
Ex.



H. Amine:

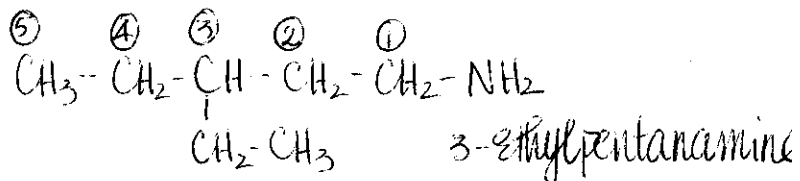


Ex.



* propanamine

Ex.

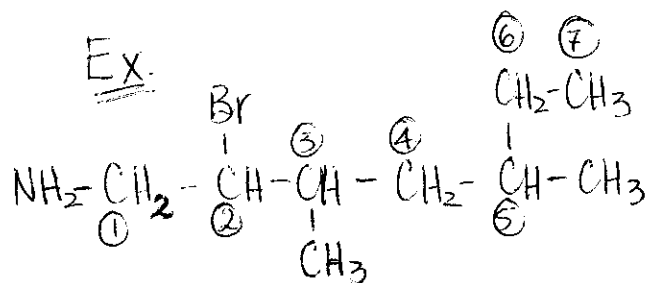


V. Cyclic Organic Compounds:

Carbon has the special ability to form extremely _____ ring (**cyclic**) structures that are either _____ or _____ bonded.

_____	_____
_____	_____

Ex.

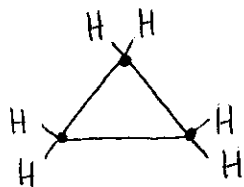


2-bromo, 3,5-dimethyl heptanamine

V. Cyclic Organic Compounds:

Carbon has the special ability to form extremely stable ring (cyclic) structures that are either singly or doubly bonded.

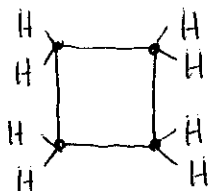
CYCLOPROPANE



or



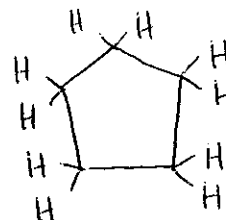
CYCLOBUTANE



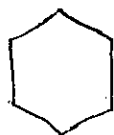
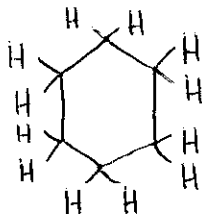
OR



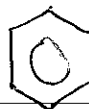
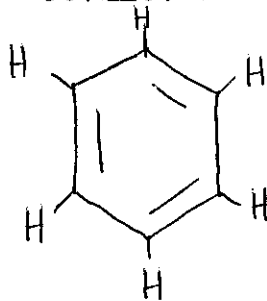
CYCLOPENTANE



CYCLOHEXANE



BENZENE



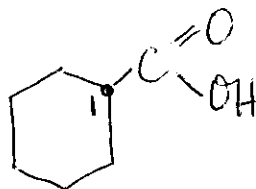
Nomenclature for Cyclic Compounds:

- 1) For substituted cyclic structures, number in a way so that the smallest # results for the substituents.
Any functional groups will get top priority.

Example:



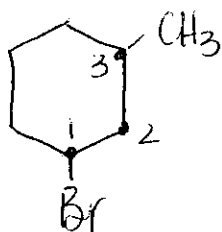
1-methylcyclopentane



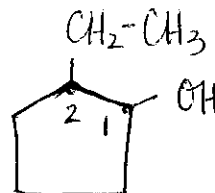
1-cyclohexanoic acid

- 2) If two or more different substituents are present, number the substituents alphabetically.

Example:



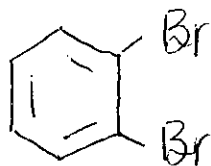
1-bromo-3-methylcyclohexane



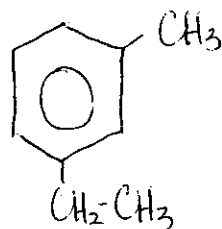
2-methyl-1-cyclopentanol

- 3) For **Benzene**, there are special prefixes that represent the placement of substituents.

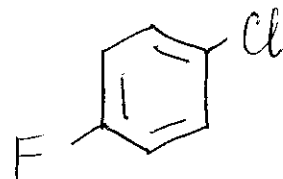
Example:



1,2 dibromobenzene
↓
ORTHO - dibromobenzene



1,3 - ethylmethylbenzene
↓
META - ethylmethylbenzene



1,4 chlorofluoro
benzene
↓
PARA - chloro
fluoro
benzene

VI. Isomerism:

Isomers: two or more molecules that share the same chemical formula, but differ in the way the atoms are bonded, or differ in the way they are spatially arranged.

There are two types of isomers:

a) **Constitutional (Structural) Isomers:** where two molecules share the same chemical formula, but the placement of the atoms differ.

b) **Stereo-Isomers:** two or more molecules that share the same physical placement of atoms, but differ in their 3-D geometry.

A. Constitutional Isomers:

- Same formulas, but differing placement of the atoms. The isomers must belong to the same family.

Example: $\text{CH}_3\text{CH}_2\text{CH}_2\text{CH}_2\text{OH}$: n-butanol ($\text{C}_4\text{H}_{10}\text{O}$)

ISOMERS: $\text{CH}_3\text{-CH}_2\text{-CH(OH)-CH}_3$: 2-butanol

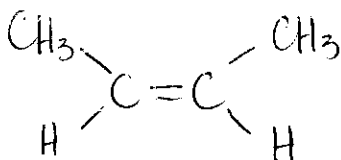
$\text{CH}_3\text{-CH(CH}_3\text{)-CH}_2\text{-OH}$: 2-methyl-1-propanol

NOTE: You have formed an isomer when the names differ from one isomer to another.

B. Stereo-Isomers - CIS/TRANS Isomers:

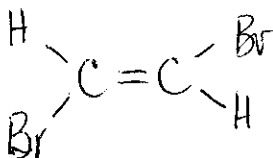
- Exists only for doubly bonded molecules.
- The double bond restricts the rotation of the bonds in space.

Example:



: CIS-1,2-dimethyl ethene

* both groups are facing the same direction.

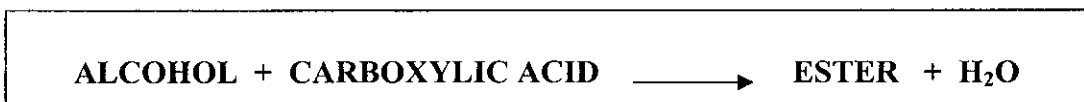


: TRANS-1,2-dibromoethene

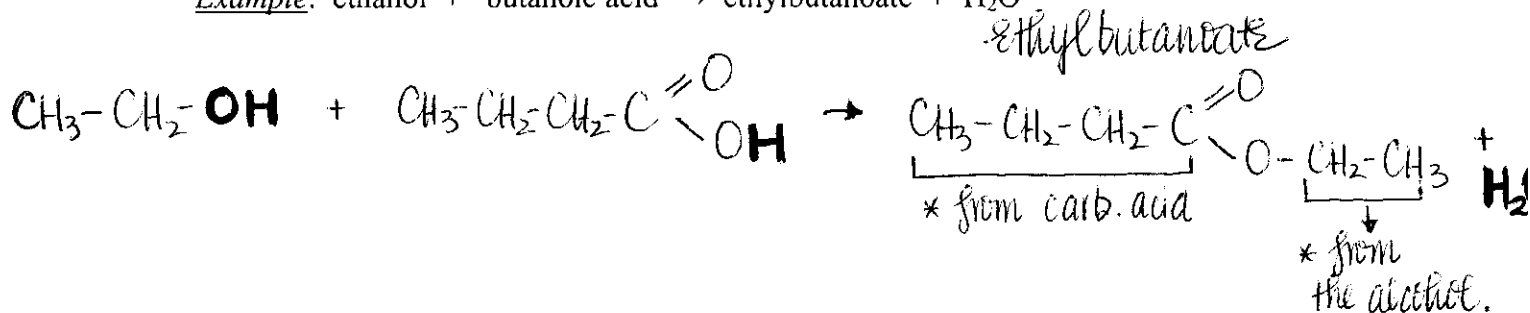
* the groups are facing opposite directions.

VII. Reactions of Organic Compounds:

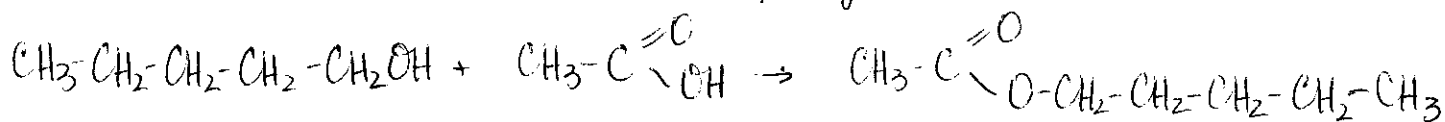
1) **Esterification:** chemical reaction that produces esters.



Example: ethanol + butanoic acid → ethylbutanoate + H₂O



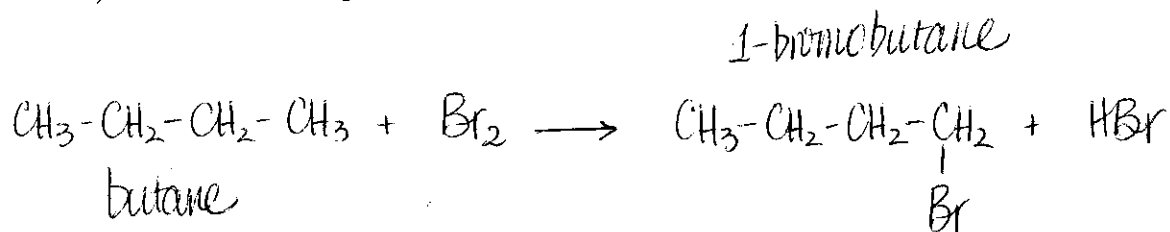
Exercise: pentanol + ethanoic acid → pentylethanoate + H₂O



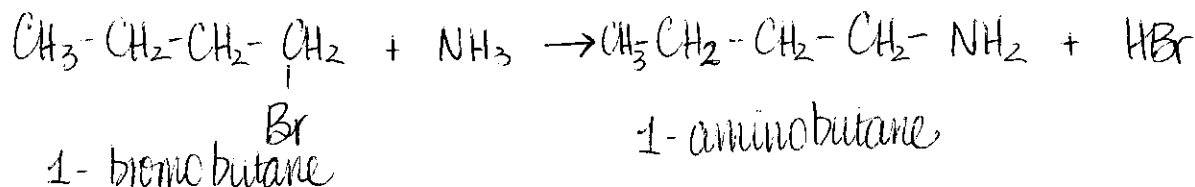
2) **Substitution Reaction:** where one or more H on an alkane is substituted with another atom or molecule.

i) ALKANE + X₂ → ALKYL HALIDE

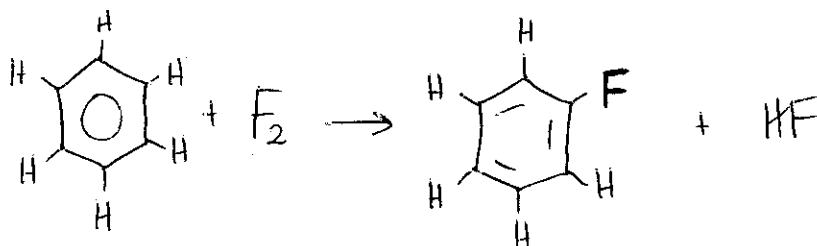
Ex.



ii) ALKYL HALIDE + NH₃ → AMINE

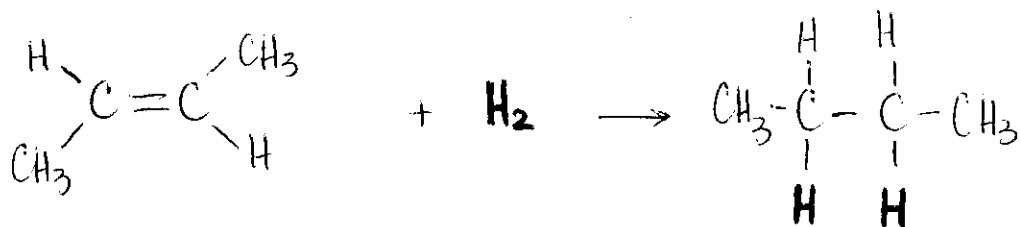


iii) BENZENE + X₂ → BENZYL HALIDE



3) **Addition Reaction:** Where the double bond or triple bond site on an alkene or alkyne is broken to form a singly bonded molecule.

i) **ALKENE + H₂ → ALKANE**



trans-1,2-dimethyl ethene

n-butane

ii) **ALKENE + HX → ALKYL HALIDE**



