# Fundamental Concept On Organic Chemistry

## Chemistry Affinity

**Conceptual, Real World and Happy Learning**

# Overview

1. Classification of organic compounds

2. Concept of aliphatic and aromatic compounds

3. Concept of aliphatic and aromatic hydrocarbons: Saturated vs unsaturated hydrocarbon

4. Concept of functional groups: alkyl halides, aryl halides, alcohol, phenol, ether, carboxylic acids, ester, nitro, amine and nitrile functional groups

5. Introduction of IUPAC nomenclature of alkane, alkenes, alkynes, haloalkane, alcohols, phenols, carbonyls and carboxylic acid

Berzelius

**Jons Jacob Berzelius first coined the term “organic chemistry” in 1806 for the study of compounds derived from biological sources.**

# Four Main Organic Compounds In Nature

Carbohydrate

Proteins

Lipids

Nucleic acids

# First Synthesis of Organic Compounds in Laboratory is Urea

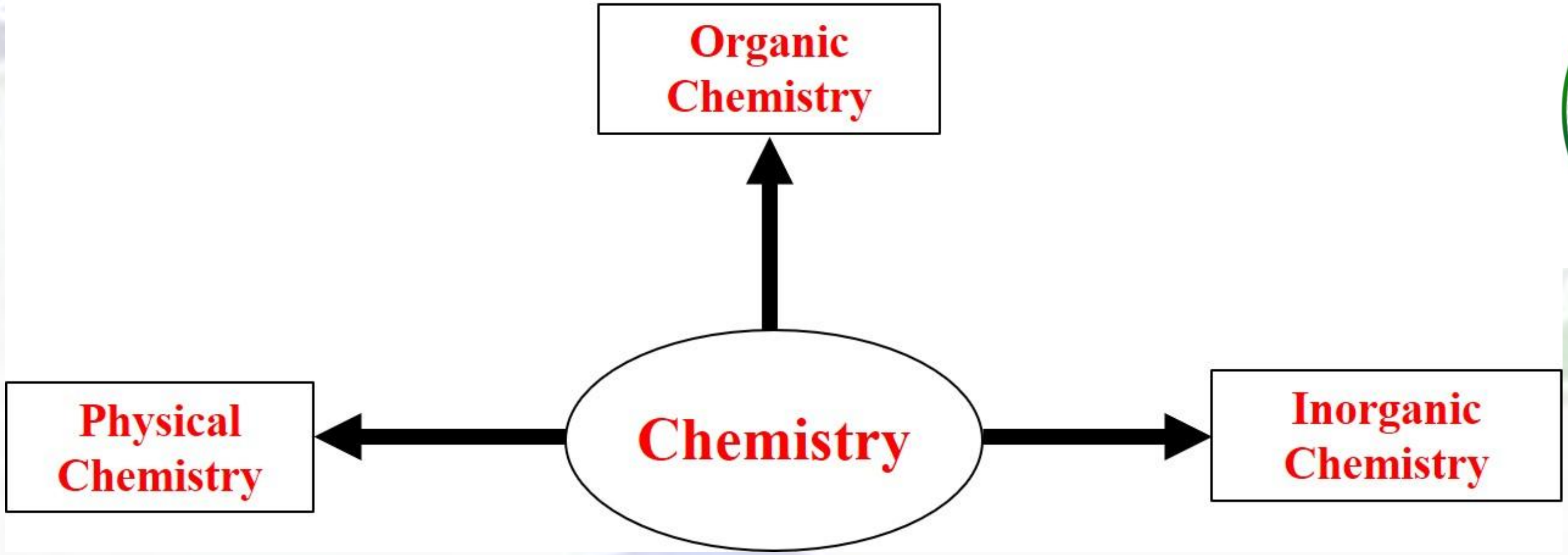
# $CO(NH_2)_2$

**Laboratory synthesis of Urea was a critical discovery because it showed that a compound known to be produced in nature only by biological organisms**

**(urea is a component of urine in many animals)**

**could be produced in a laboratory under controlled conditions**


**In 1828, Friedrich Wöhler successfully synthesized urea by heating ammonium cyanate in laboratory. It is known as the "Wöhler synthesis."**



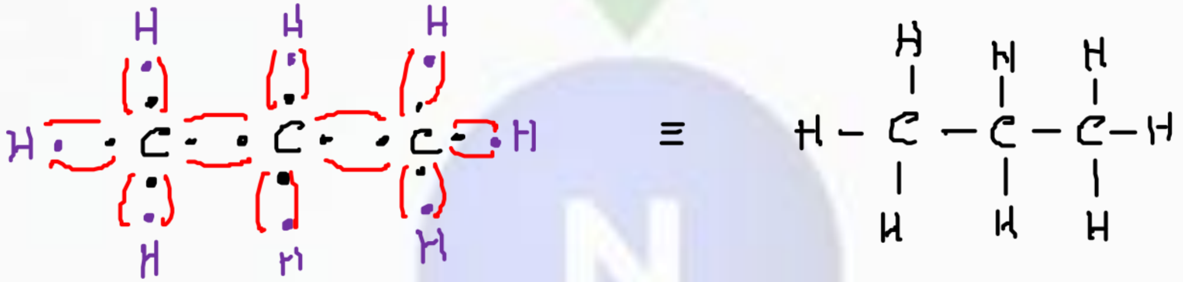

**Organic chemistry is the study of the chemistry of carbon compounds**

- **Carbon atoms bond reasonably strong bonds with other carbon atoms**
- **Carbon atoms also can bond with atoms of other elements like hydrogen, nitrogen , phosphorous etc.**
- **Carbon atoms make a large number of covalent bonds (four) with other elements**

# Electronic Configuration: Carbon

**Carbon has 4 valence electrons in its valence orbitals**

**Therefore, carbon atom can form four covalent bonds with other atoms is called tetravalency**



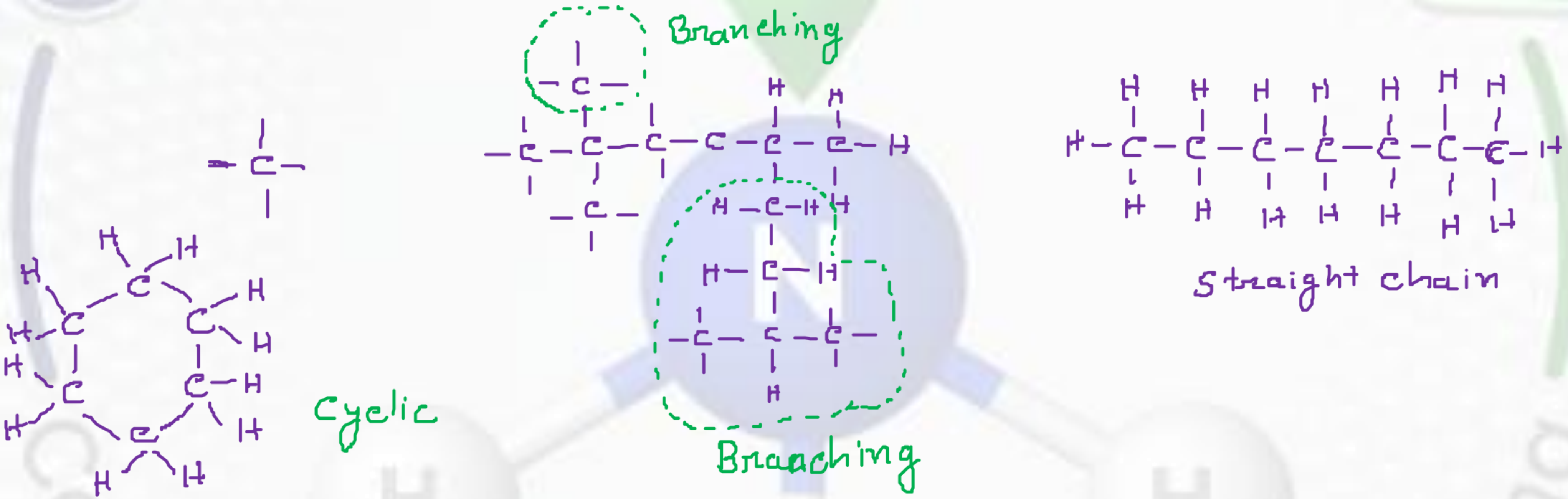
**These C-C covalent bonds are strong in nature**

**The small size of the carbon atom makes the compounds of Carbon exceptionally stable**

**Hence carbon as an element has the ability to form a variety of stable compounds, which can exist freely in nature**

# Catenation Property

**Carbon has a bonding capacity of 4, so carbon can make bond with another carbons, hydrogens, and other elements extensively. This property is called catenation**



# Catenation Property

**Due to its tetravalent nature carbon can form bonds with other atoms of carbon to form**

**(i) Straight chain,**

**(ii) Branched chain,**

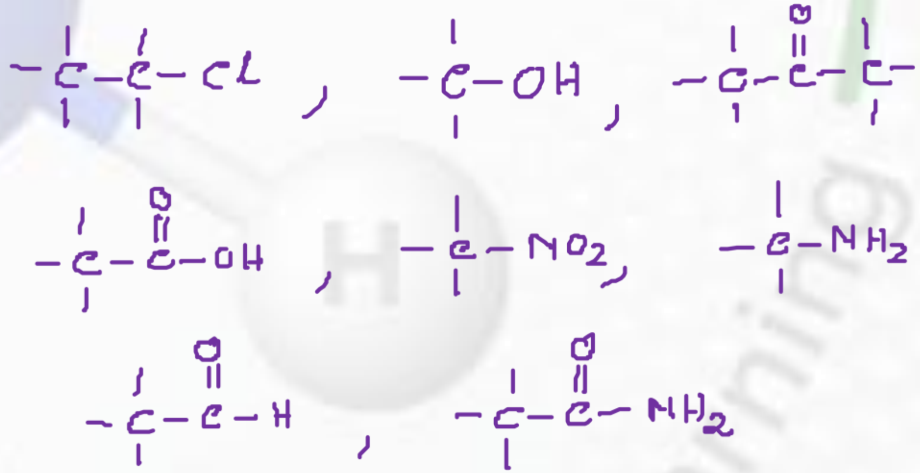
**And**

**(iii) Cyclic or ring structure**

# Classification: Organic compounds

## Organic Compounds

**Hydrocarbons** | **Functional groups**



# Hydrocarbons

- Aliphatic
  - Acyclic
    - Alkane
    - Alkene
    - Alkyne
  - cyclic
    - Alkane
    - Alkene
- Aromatic
  - cyclic

# Saturated and Unsaturated Organic Compounds

- Alkane
  - Saturated
    - Only C-C single bond
- Alkene
- Alkyne
  - Unsaturated (Alkene, Alkyne)
    - Aromatic

**Alkene:** At least one C-C double bond

**Alkyne:** At least one C-C triple bond

**Aromatic:** Alternate C-C Single bond and C-C double bond

# Hydrocarbons

**Simplest organic compounds are hydrocarbons which contains carbon and hydrogen only**

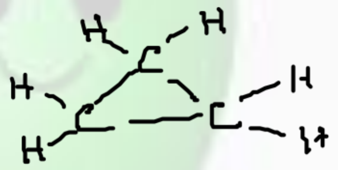
**Saturated hydrocarbons have only C-C and C-H single bonds: Alkane**

**Unsaturated hydrocarbons contain C-C double or triple bonds along with C-H single bonds: Alkene or Alkyne**

# Hydrocarbons are two types: Cyclic or Acyclic

$H_3C-CH_2-CH_3$

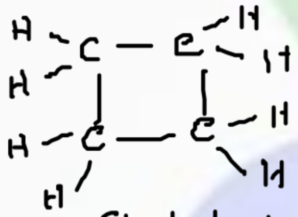
Propane



Cyclopropane

$H_3C-CH_2-CH_2-CH_3$

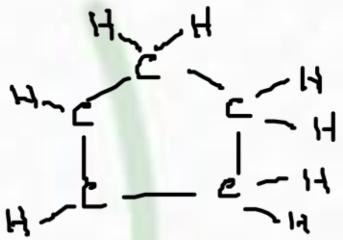
Butane



Cyclobutane

$H_3C-CH_2-CH_2-CH_2-CH_3$

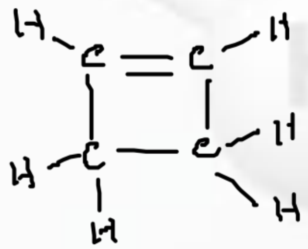
pentane



cyclopentane

# Cyclic and acyclic hydrocarbons are again two types: Saturated and Unsaturated

$H_2C=CH-CH_2-CH_3$



# Aliphatic Acyclic Hydrocarbons: Alkane, Alkene and Alkyne

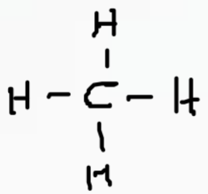
**Alkanes, alkenes, and alkynes are all classified as hydrocarbons, because they are composed solely of carbon and hydrogen atoms**

# Organic Chemistry:
# Number of carbons

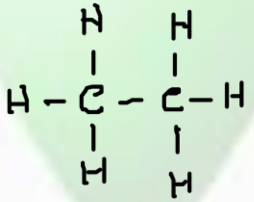
**One Carbon: meth,**
**Two carbons: Eth**
**Three carbons: Prop,**
**Four carbons: But**
**Five carbons: Pent**
**Six carbons: Hex**
**Seven carbons: Hept**
**Eight carbons: Oct**
**Nine cardons: Non**
**Ten carbons: Deca**

# Finding out sigma and pi bonds in hydrocarbons

Four C-H single bonds or sigma bonds

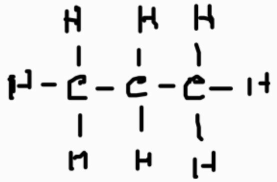



Methane




Ethane

Six C-H and one C-C single bonds or sigma bonds



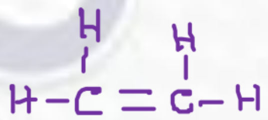

Propane

Eight C-H and two C-C single bonds or sigma bonds

All these hydrocarbons are straight chain molecules, so, these are called **aliphatic acyclic**

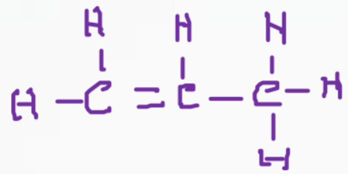
**They contain only C-C and C-H,**
**These types of hydrocarbons are called alkanes**

# Unsaturated Hydrocarbons: Alkene (Acyclic)




**Ethene**

**Four C-H and one C-C single bonds or sigma bonds One C=C double bond**




**Propene**

**Six C-H and two C-C single bonds or sigma bonds One C=C double bond**

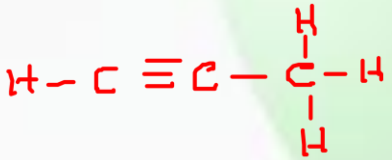
**All these hydrocarbons are straight chain molecules, so these are called aliphatic acyclic**

**They contain C-C single and C=C, double bonds so these hydrocarbons are called alkenes**

# Unsaturated Hydrocarbons: Alkyne (Acyclic)

Acetylene

Two C-H and one C-C single bonds or sigma bonds Two C=C double bond



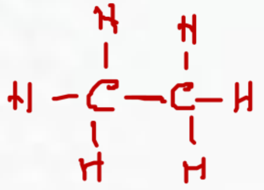
Propyne

Four C-H and two C-C single bonds or sigma bonds Two C=C double bond

All these hydrocarbons are straight chain molecules, so these are called **aliphatic acyclic**

**They contain C-C single and C-C Triple bonds so these hydrocarbons are called alkynes**

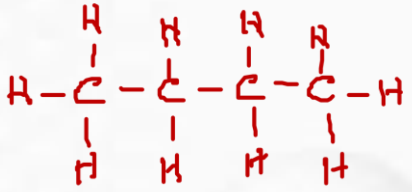
# Practice: Saturated and Unsaturated Organic Compounds



Single bond: σ bond

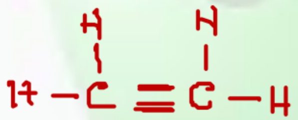
C-C : σ bond : 1

C-H : σ bond : 6



C-C σ bond: 3

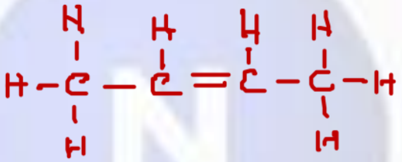
C-H σ bond : 10



C-C : σ bond = 1

C-C : π bond = 1

C-H : σ bond = 4



C-C : 3 σ bond

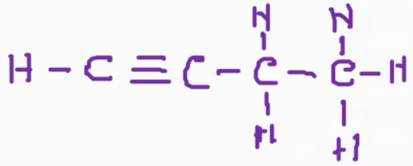
C-C : one π bond

C-H : 8 σ bond

C-C : 1 σ bond

C-C : 2 π bond

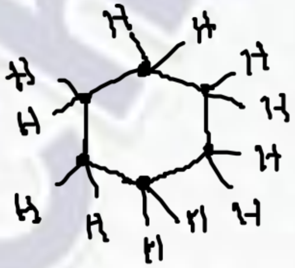
C-H : 2 σ bond



C-C : σ bond : 3

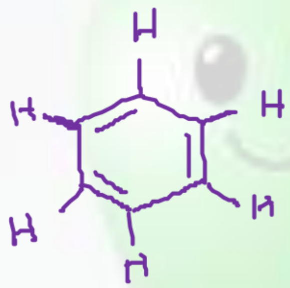
C-C : π bond : 2

C-H : σ bond : 6



C – C : σ bond : 6

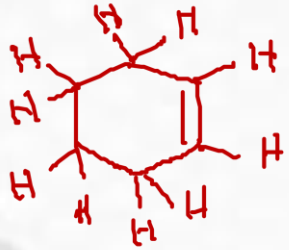
C – H : σ bond : 12



C – C : σ : 6

C – C : π bond : 3

C – H : σ bond : 6



C – C : σ bond : 6

C – C : π bond : 1

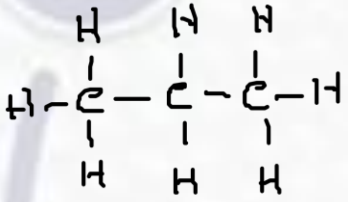
C – H : σ bond : 10

# General Formula: Alkane, Alkene and Alkyne

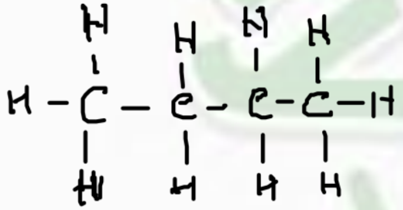
| | |
|---|---|
| Alkane | General formula: $C_nH_{2n+2}$ |
| Alkene | General formula: $C_nH_{2n}$ |
| Alkyne | General formula: $C_nH_{2n-2}$ |

# Let's Explore Aliphatic Saturated Hydrocarbons: Alkane

# Saturated Hydrocarbons and Real World



Propane

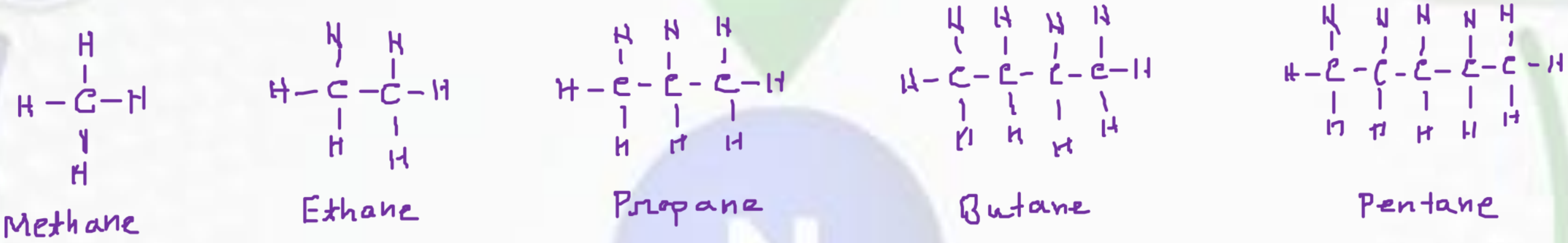



Butane

**LPG is composed hydrocarbons containing three or four carbon atoms. The normal components of LPG thus, are propane ($C_3H_8$) and butane ($C_4H_{10}$)**

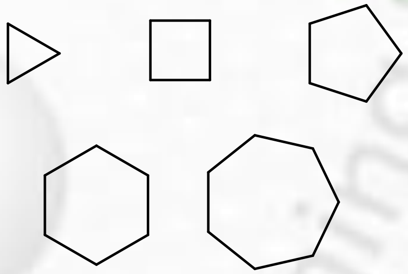
# Alkanes: Saturated Hydrocarbons

**Hydrocarbons that have no double or triple bond or functional groups are classified as alkanes or cycloalkanes. These are called saturated compounds**



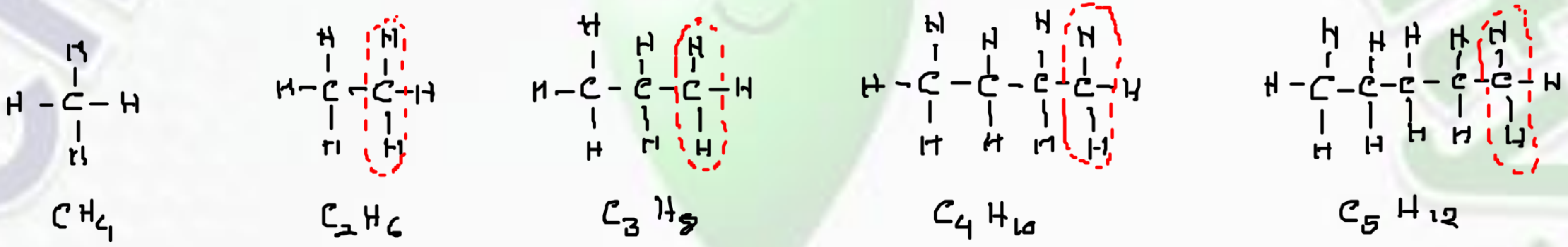

**Alkanes: carbon atoms of the molecule are arranged only in chains**

**Cycloalkanes: carbon atoms of the molecule are arranged only in rings**



$C_nH_{2n+2}$ → **General formula of alkane**

# Homologous Series

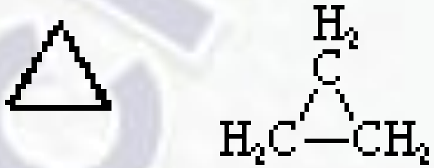



**A uniform variation of this kind (increasing -$CH_2$) in a series of compounds is called homologous series**

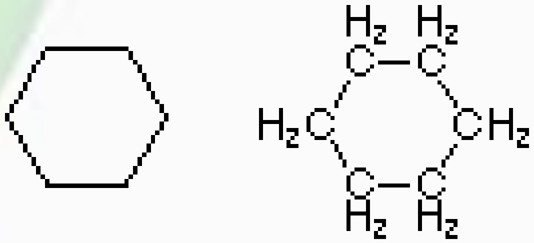
# Saturated Hydrocarbons

| Name | Molecular Formula | Structural formula | Carbon number |
|---|---|---|---|
| methane | $CH_4$ | $CH_4$ | 1 |
| ethane | $C_2H_6$ | $CH_3CH_3$ | 2 |
| propane | $C_3H_8$ | $CH_3CH_2CH_3$ | 3 |
| butane | $C_4H_{10}$ | $CH_3CH_2CH_2CH_3$ | 4 |
| pentane | $C_5H_{12}$ | $CH_3(CH_2)_3CH_3$ | 5 |
| hexane | $C_6H_{14}$ | $CH_3(CH_2)_4CH_3$ | 6 |
| heptane | $C_7H_{16}$ | $CH_3(CH_2)_5CH_3$ | 7 |
| octane | $C_8H_{18}$ | $CH_3(CH_2)_6CH_3$ | 8 |
| nonane | $C_9H_{20}$ | $CH_3(CH_2)_7CH_3$ | 9 |
| decane | $C_{10}H_{22}$ | $CH_3(CH_2)_8CH_3$ | 10 |

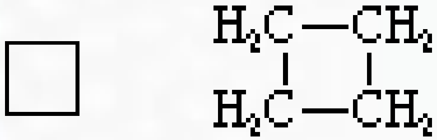
# Cyclic Saturated Hydrocarbons



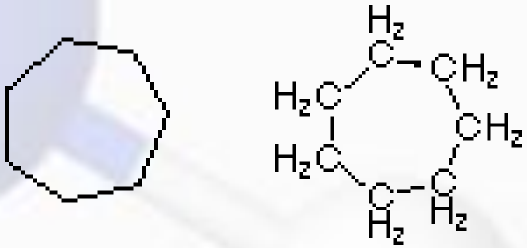
**Cyclopropane**



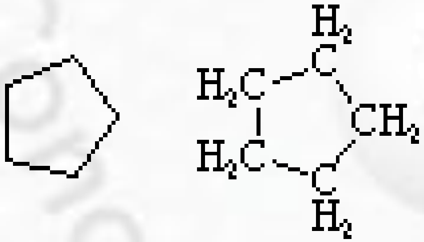
**Cyclohexane**



**Cyclobutane**



**Cycloheptane**



**Cyclopentane**

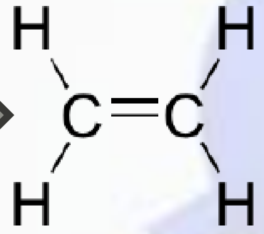
# Let's Explore Aliphatic Unsaturated Hydrocarbons:

# Alkenes and Alkynes

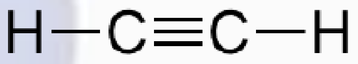
# Unsaturated Hydrocarbons: Alkene and Alkyne

**Unsaturated hydrocarbons that contain one or more double bonds or triple bonds**

**Simplest Alkene**




ethene
(an alkene)




ethyne
(an alkyne)

**Acetylene**

**Simplest Alkyne**

# Ethylene: Real World


**Ethylene is an important plant hormone**

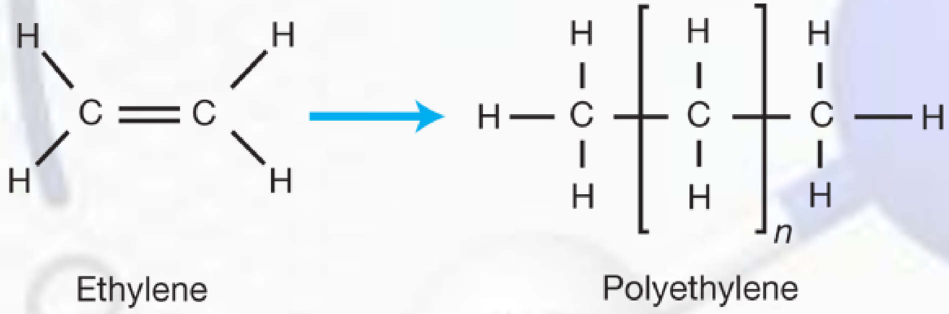
**In bananas and many other fruits, production of ethylene surges when the fruit is ready to ripen**

**This surge triggers the transformation of a hard, green, dull fruit into a tender, gaudy, sweet thing that's ready-to-eat**

https://courses.lumenlearning.com/suny-orgbiochemistry/chapter/4-6-introduction-to-organic-chemistry/

# Ethylene: Polymers

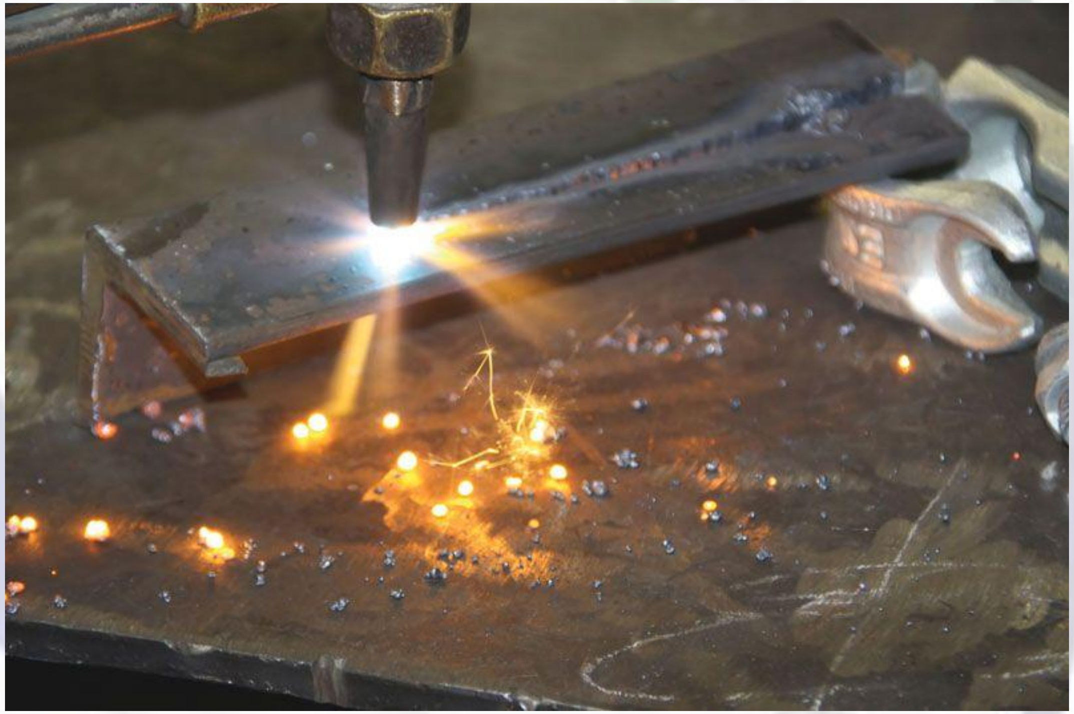
**Ethylene is widely used in the chemical industry to produce polyethylene, which is a widely used plastic that contains polymer chains of ethylene**




# Acetylene: Real World


**Acetylene is a colorless Pungent smelling Organic compound**

**It burns with a bright flame and used in welding**



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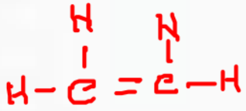
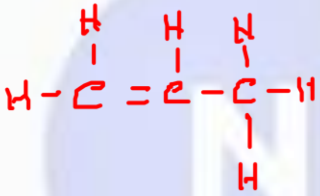
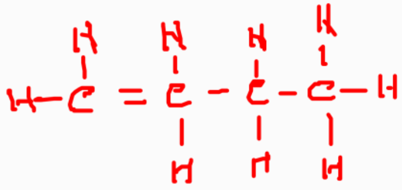
# **Unsaturated Hydrocarbons**

**The double and triple-bonded carbons in alkenes and alkynes have fewer hydrogen atoms bonded to them - they are referred to as unsaturated hydrocarbons**

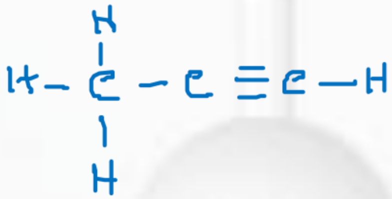
## **Alkene**

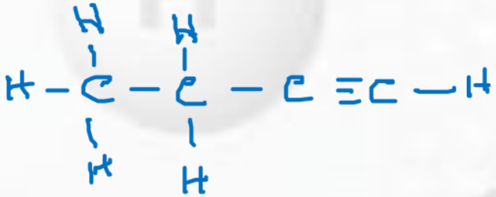






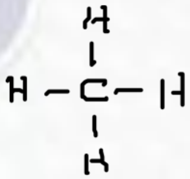
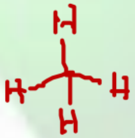
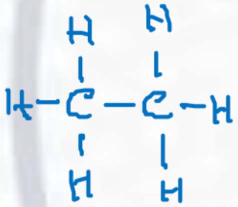
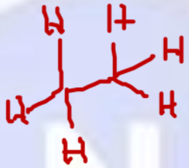
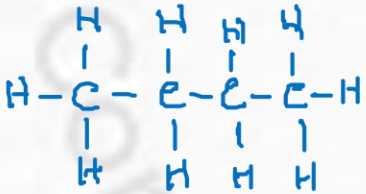
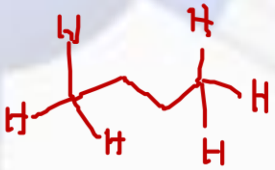
## **Alkyne**



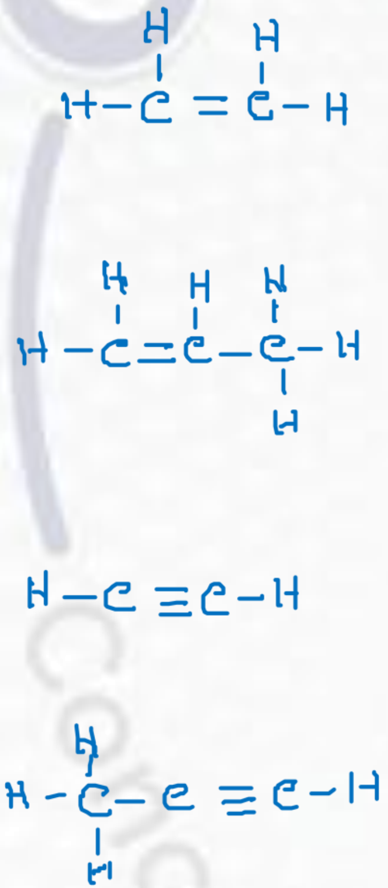


# How to write organic molecules?

# Dash Formula, Condensed Formula and Bond Line

| Dash Formula | | Condensed Formula | | Bond line Formula | Name |
|---|---|---|---|---|---|
|  | ≡ | $CH_4$ | ≡ |  | Methane |
|  | ≡ | $CH_3CH_3$ | ≡ |  | Ethane |
|  | ≡ | $H_3CCH_2CH_2CH_3$ | ≡ |  or  | Butane  |

| Dash Formula | Condensed Formula | Bond line Formula | Name |
|---|---|---|---|
| | | | |

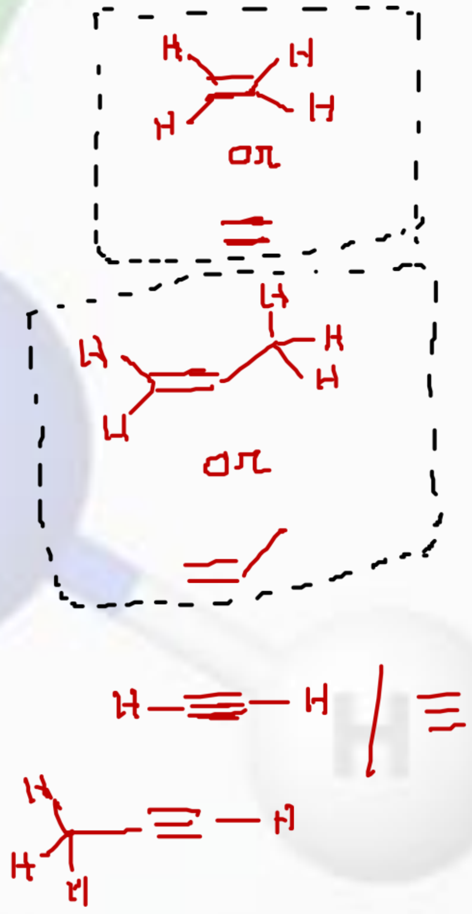


$H_2C=CH_2$

$H_2C=CHCH_3$

$C_2H_2$ | $HC\equiv CH$

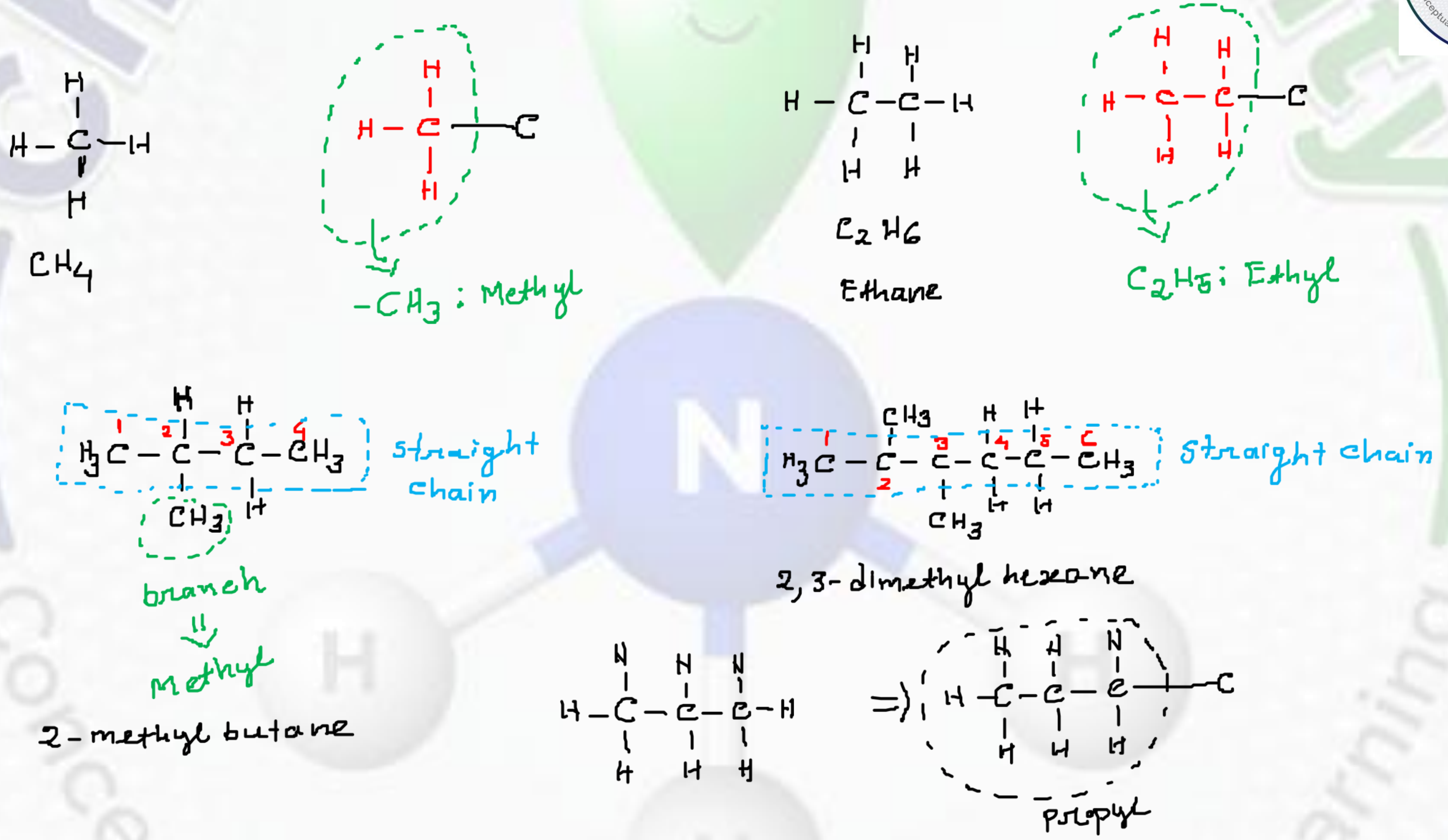
$H_3C\,C\equiv CH$




Ethylene | Ethene

# Let’s Understand Methyl, Ethyl, Propyl, Butyl Groups In Chemistry

# Concept of Methyl, Ethyl



| Group | Name | Group | Name |
|---|---|---|---|
| $CH_3$– | Methyl | $CH_3CH_2CH_2CH_2$– | Butyl |
| $C_2H_5$– | Ethyl | $(CH_3)_2CHCH_2$– | Isobutyl |
| $CH_3CH_2CH_2$– | Propyl | $CH_3CH_2CH(CH_3)$– | sec-Butyl |
| $(CH_3)_2CH$– | Isopropyl | $(CH_3)_3C$– | tert-Butyl |

# IUPAC Nomenclature of Alkane

Simple continuous-chain alkanes from C-1 to C-10

## A common "ane" suffix identifies these compounds as alkanes

| Name | Molecular Formula | Structural formula | Isomer |
|---|---|---|---|
| methane | $CH_4$ | $CH_4$ | 1 |
| ethane | $C_2H_6$ | $CH_3CH_3$ | 1 |
| propane | $C_3H_8$ | $CH_3CH_2CH_3$ | 1 |
| butane | $C_4H_{10}$ | $CH_3CH_2CH_2CH_3$ | 2 |
| pentane | $C_5H_{12}$ | $CH_3(CH_2)_3CH_3$ | 3 |
| hexane | $C_6H_{14}$ | $CH_3(CH_2)_4CH_3$ | 5 |
| heptane | $C_7H_{16}$ | $CH_3(CH_2)_5CH_3$ | 9 |
| octane | $C_8H_{18}$ | $CH_3(CH_2)_6CH_3$ | 18 |
| nonane | $C_9H_{20}$ | $CH_3(CH_2)_7CH_3$ | 35 |
| decane | $C_{10}H_{22}$ | $CH_3(CH_2)_8CH_3$ | 75 |

# IUPAC Rules for Alkane

1. Find and name the longest continuous carbon chain

2. Identify and name groups attached to this chain

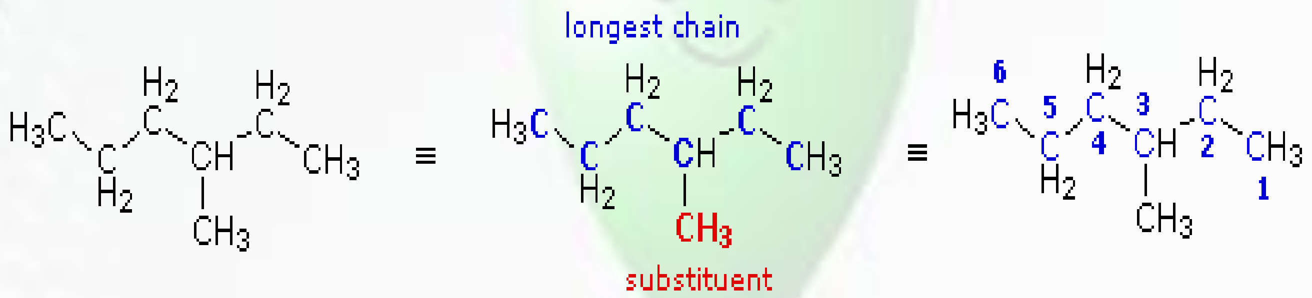
3. Number the chain consecutively, starting at the end nearest a substituent group

4. Designate the location of each substituent group by an appropriate number and name.

5. Assemble the name, listing groups in alphabetical order using the full name (e.g. cyclopropyl before isobutyl)

6. The prefixes di, tri, tetra etc., used to designate several groups of the same kind, are not considered when alphabetizing

# IUPAC Nomenclature of Alkane: Example



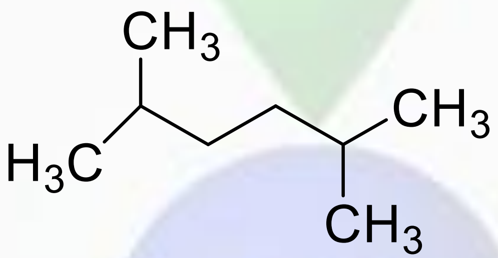

**the longest chain is seen to consist of six carbons, so the root name of this compound will be hexane**

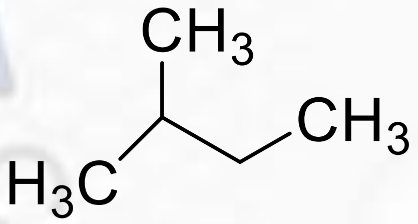
**A single methyl substituent (colored red) is present, so this compound is a methylhexane. The location of the methyl group must be specified**

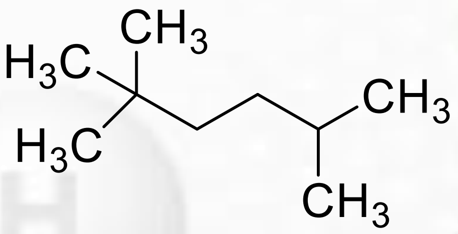
**To locate the substituent on the hexane chain, numbering should be given accordingly starts from the end nearest to substituent**

**The IUPAC name: 3-methylhexane**

# Write down IUPAC Nomenclature of Alkane



# Alkene and Alkyne

| | | |
|---|---|---|
| **Alkene** | **R–CH=CH–R** | **General formula: $C_nH_{2n}$** |
| **Alkyne** | **R–C≡C–R** | **General formula: $C_nH_{2n-2}$** |

**1. The ene suffix (ending) indicates an alkene or cycloalkene**

**2. The longest chain chosen for the root name must include both carbon atoms of the double bond.**

# IUPAC Nomenclature of Alkene

3. The root chain must be numbered from the end nearest to double bond carbon atom. If the double bond is in the center of the chain, the nearest substituent rule is used to determine the end where numbering starts

4. If more than one double bond is present the compound is named as a diene, triene or equivalent prefix indicating the number of double bonds.

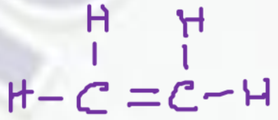
# IUPAC Nomenclature of Alkene

1. The ene suffix (ending) indicates an alkene

2. The longest chain chosen for the root name must include both carbon atoms of the double bond

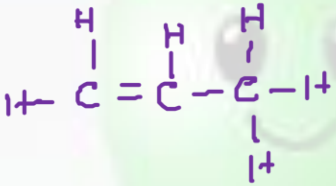
3. The root chain must be numbered from the end nearest to double bond carbon atom

4. If more than one double bond is present the compound is named as a diene, triene or equivalent prefix indicating the number of double bonds



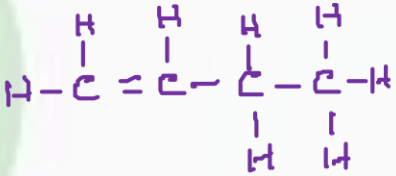
$C_2H_4$

Ethylene

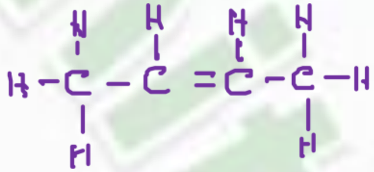


$C_3H_6$

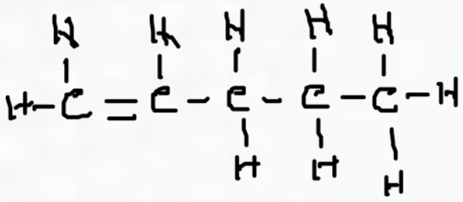
Propene



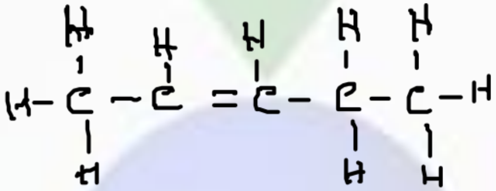
1- Butene



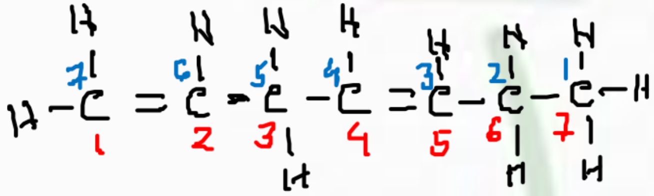
2 - Butene



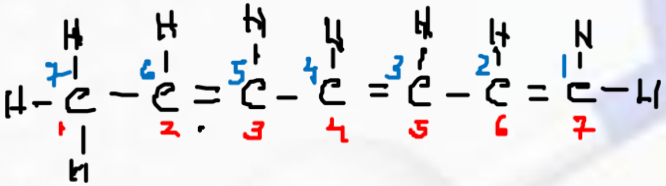
1 - pentene



2- pentene

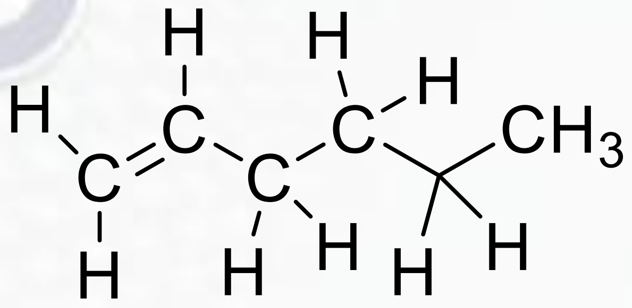


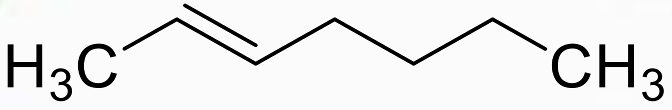
1, 4- heptadiene

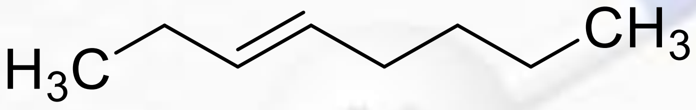


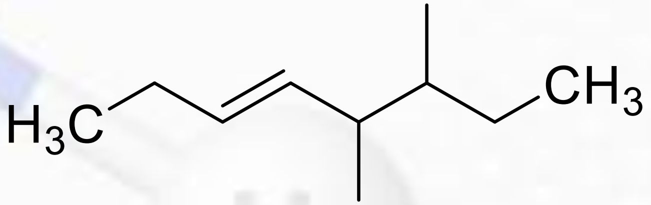
1, 3, 5- heptatriene

# IUPAC Nomenclature: Alkene



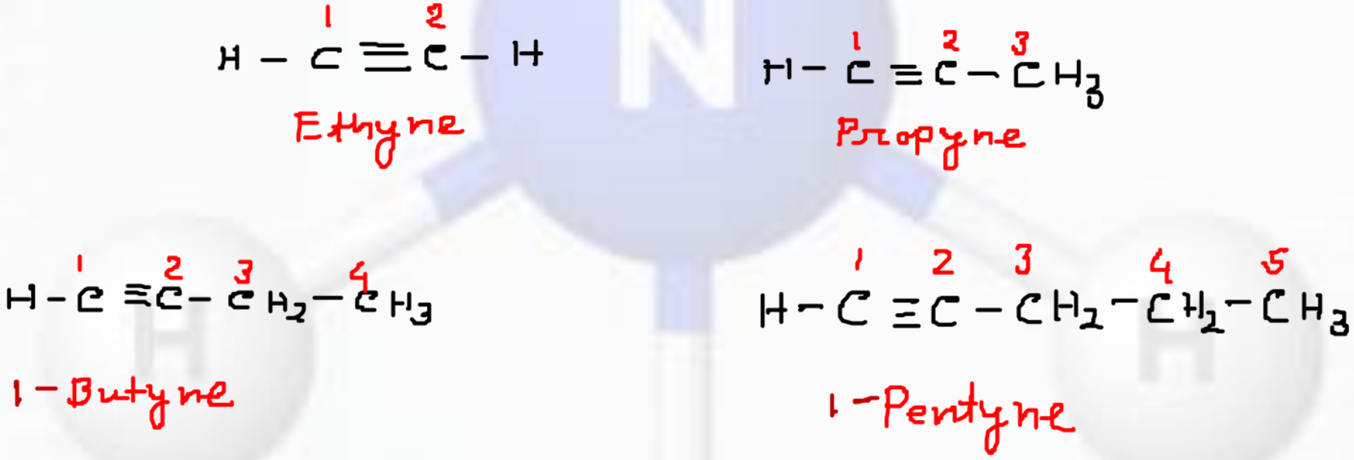



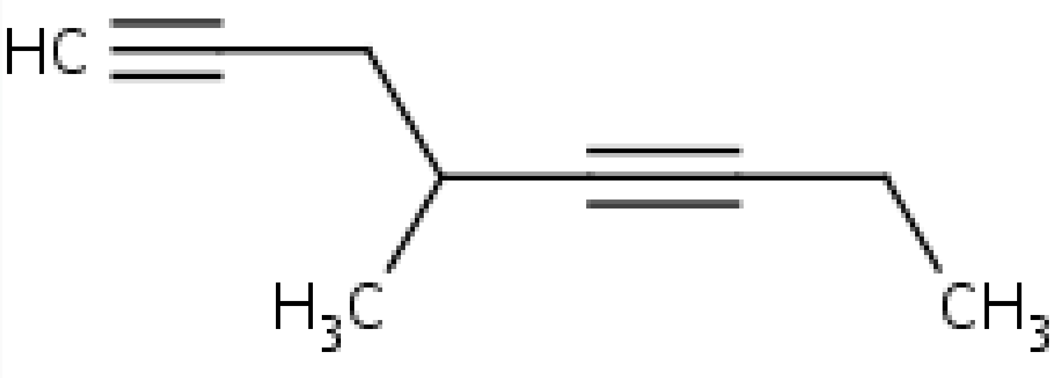
# IUPAC Nomenclature of Alkyne

**Alkynes are organic molecules made of the functional group carbon-carbon triple bonds**

**Like alkenes have the suffix –ene, alkynes use the ending –yne**



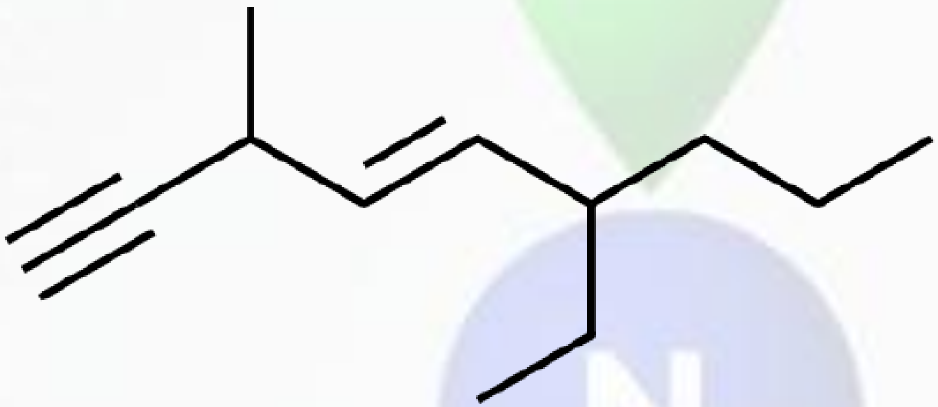
**When there are two triple bonds in the molecule, find the longest carbon chain including both the triple bonds. Number the longest chain starting at the end closest to the triple bond that appears first. The suffix that would be used to name this molecule would be –diyne**

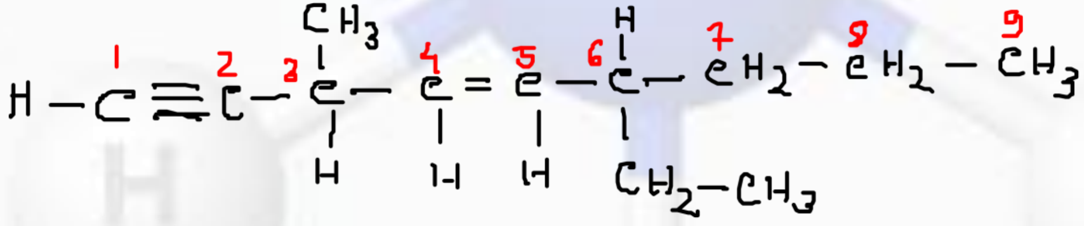



**4-methyl-1,5-octadiyne**

# IUPAC Nomenclature of Alkyne

**If a molecule contains both a double and a triple bond, the carbon chain is numbered so that the first multiple bond gets a lower number**

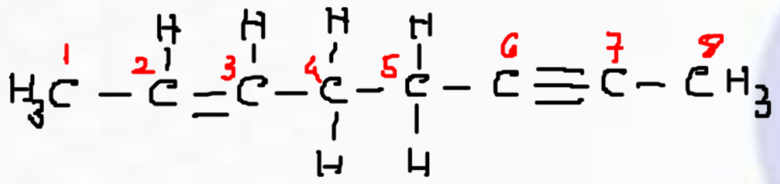




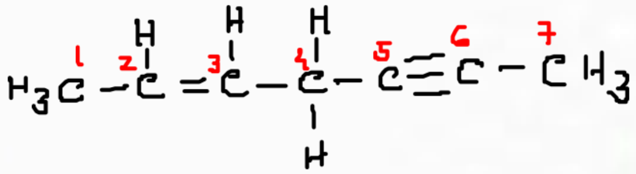

**6-ethyl-3-methylnon-4-en-1-yne**

# IUPAC Nomenclature of Alkyne

**If both bonds can be assigned the same number, the double bond takes precedence. The molecule is then named "n-en-n-yne", with the double bond root name preceding the triple bond root name**



**Oct-2-ene-6-yne**

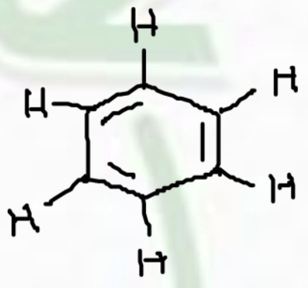


**hept-2-ene-5-yne**

# Aromatic Hydrocarbon

**They also contain C-C sigma bonds, C-C pi bonds and C-H sigma bonds**

**They are cyclic and planar**



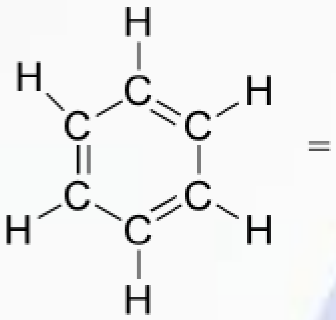

Benzene

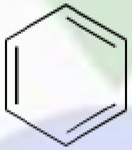
**They have alternate single and double bond which is known as conjugation**

**They follow Huckel's rule (4n+2)Π electrons**
**n = 0, 1, 2, 3.......**

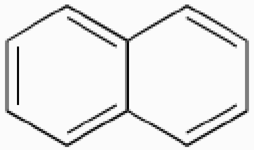
# Cyclic Hydrocarbons: Aromatic

## The aromatic group is usually exemplified by benzene

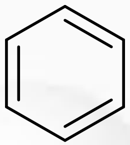


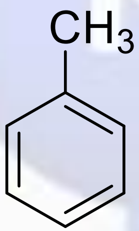



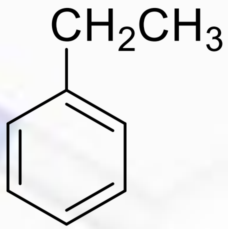
benzene

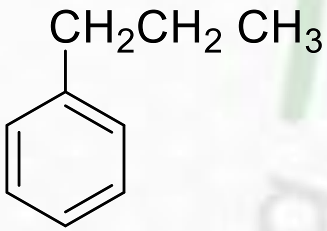


napthalene





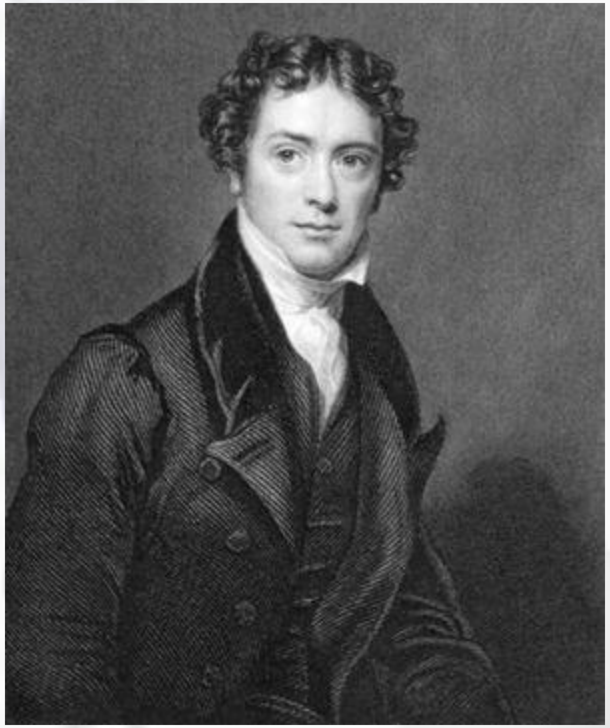



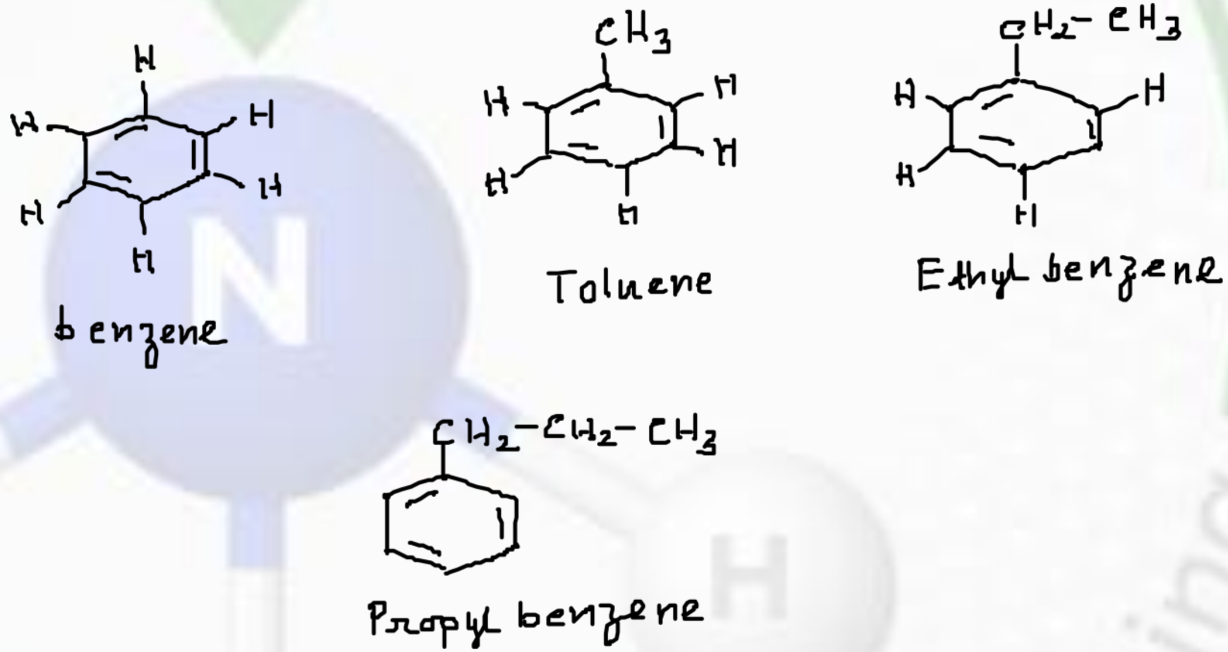




| | Benzene | Toluene | Ethyl benzene | Propyl benzene |
|---|---|---|---|---|
| **Molecular Formula** | $C_6H_6$ | $C_7H_8$ | $C_8H_{10}$ | $C_9H_{12}$ |

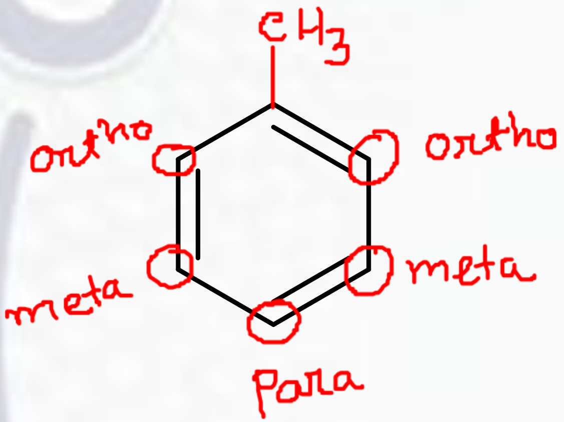
# Discovery of benzene

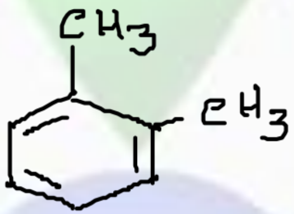
## Benzene was first discovered by an English scientist Michael Faraday in 1825





# Aromatic compound: Concept of Ortho, meta and para



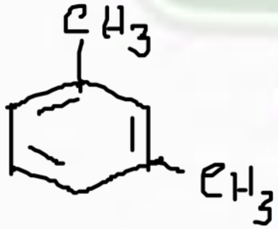




Ortho-methyl toluene

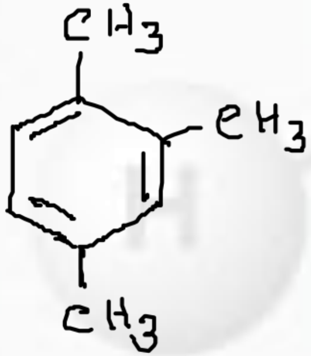
o-xylene

**2-methyl toluene**

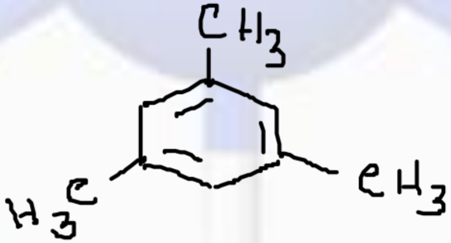
**3-methyl toluene**



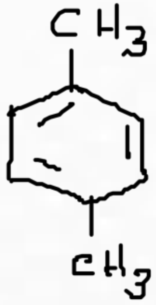

**Meta-methyl toluene**
**Or m-xylene**




**2,4-dimethyl toluene**



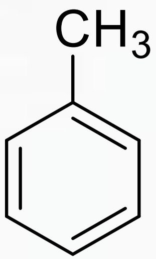

**3,5-dimethyl toluene**



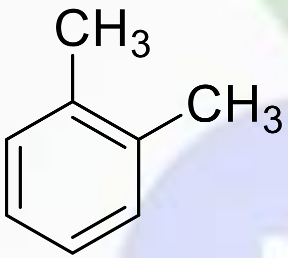

**para-methyl toluene**
**Or p-xylene**

**4-methyl toluene**

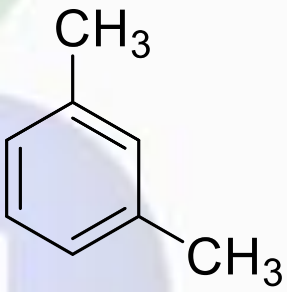
# Aromatic Hydrocarbons are available in crude oil



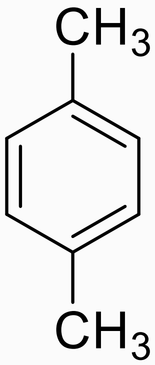

**Toluene**




**o-methyl toluene Or o-xylene**




**m-methyl toluene Or m-xylene**



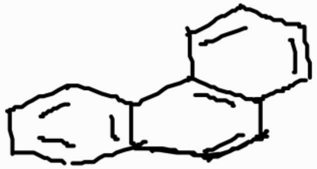

**p-methyl toluene Or p-xylene**

# Polycyclic Aromatic Hydrocarbon (PAH)

**PAH consist of fused benzene rings**

**Naphthalene**

**Anthracene**



**Phenanthrene**

**These PAHs are colorless, crystalline solids generally obtained from coal tar**

**Naphthalene has a pungent odor and is used in mothballs**

**Anthracene is used in the manufacture of certain dyes**

**Steroids, including cholesterol and the hormones, estrogen and testosterone, contain the phenanthrene structure**

# Bond length:

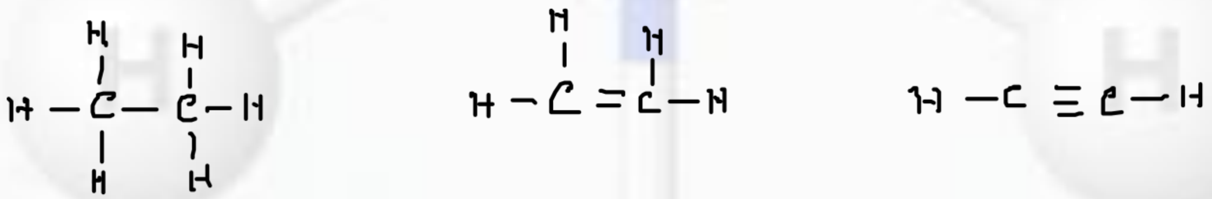
## Single bond, Double bond and Triple bond in aliphatic compounds and in Aromatic Compounds

**Experimental studies (X-ray diffraction) show that Bond length of (Aliphatic Compounds)**

**C-C single bond = 1.46 Å**

**C=C doble bond = 1.34 Å**

**C-C triple bond = 1.20 Å**



# Fundamental
# Organic Reactions

# Combustion Reaction

**A combustion reaction is an exothermic reaction**

**This reaction is between a fuel (hydrocarbons) and an oxidizer that forms an oxidized product**

# Examples: Combustion Reaction

**Combustion of methane: $CH_4(g) + 2\ O_2(g) \rightarrow CO_2(g) + 2\ H_2O(g)$**

**Burning of naphthalene: $C_{10}H_8 + 12\ O_2 \rightarrow 10\ CO_2 + 4\ H_2O$**

**Combustion of ethane: $2\ C_2H_6 + 7\ O_2 \rightarrow 4\ CO_2 + 6\ H_2O$**

**Combustion of butane (commonly found in lighters):**
**$2C_4H_{10}(g) + 13O_2(g) \rightarrow 8CO_2(g) + 10H_2O(g)$**

**Combustion of methanol (also known as wood alcohol):**
**$2CH_3OH(g) + 3O_2(g) \rightarrow 2CO_2(g) + 4H_2O(g)$**

**Combustion of propane (used in gas grills, fireplaces, and some cookstoves):**
**$2C_3H_8(g) + 7O_2(g) \rightarrow 6CO_2(g) + 8H_2O(g)$**

# Complete Vs Incomplete Combustion Reaction

**Complete combustion fully utilizes oxygen. Reactant is fully consumed while reacts with oxygen. No carbon residue left**

$$C_3H_8(g) + 5O_2(g) \longrightarrow 3CO_2(g) + 4H_2O(g)$$

**Incomplete combustion forms carbon monoxide and carbon which is harmful for environment**

$$2C_3H_8 + 7O_2(g) \longrightarrow 2CO_2 + 8H_2O + 2C + 2CO$$

# Cracking of Hydrocarbons

**Cracking is breaking up the large hydrocarbon molecules into smaller and more useful hydrocarbons which we need for daily purpose**

**Cracking is achieved by using high pressures and temperatures without a catalyst, or lower temperatures and pressures in the presence of a catalyst**

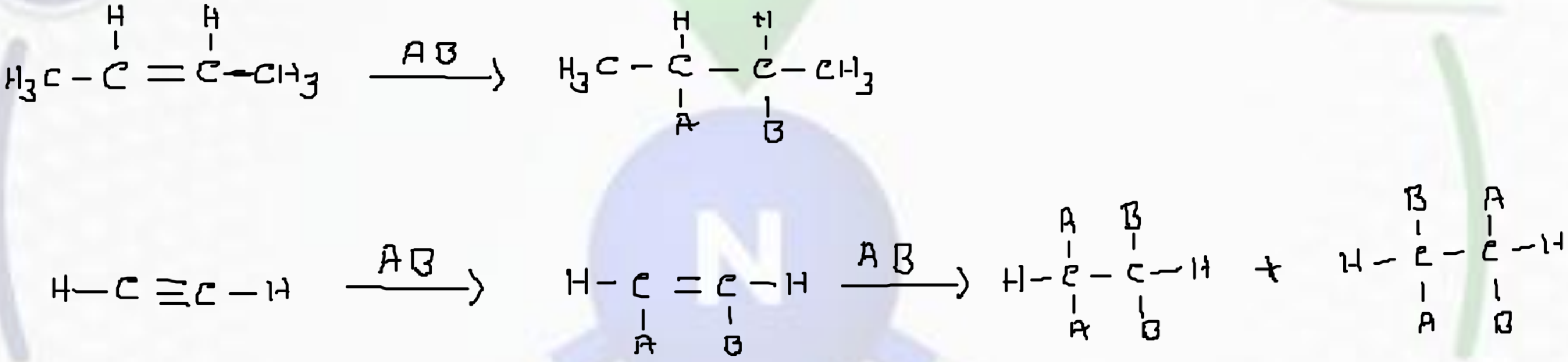
$$C_{15}H_{32} \xrightarrow[\text{high pressure}]{\text{high temp}} 2\,C_2H_4 + C_3H_6 + C_8H_{18}$$

ethene — propane — octane

$H_2C=CH_2$ — $H_3C-CH_2-CH_3$ — $CH_3CH_2CH_2CH_2CH_2CH_2CH_2CH_3$

# Important Reactions of Alkenes and Alkyne

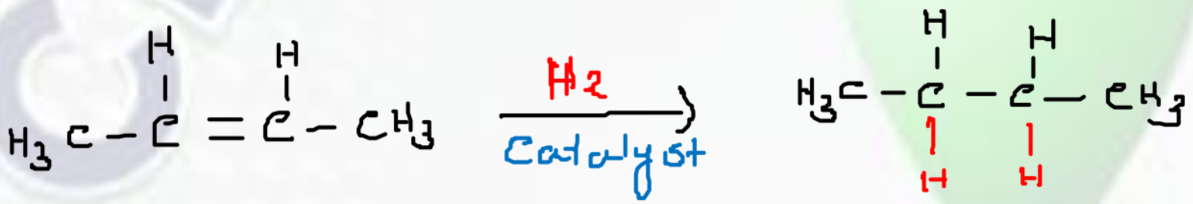
## Addition Reaction




**This type of reaction is called addition reaction, where alkene converts to alkane**

**Alkyne converts to alkene and finally to alkane**

# Example: Addition Reaction




**Hydrogenation reaction**

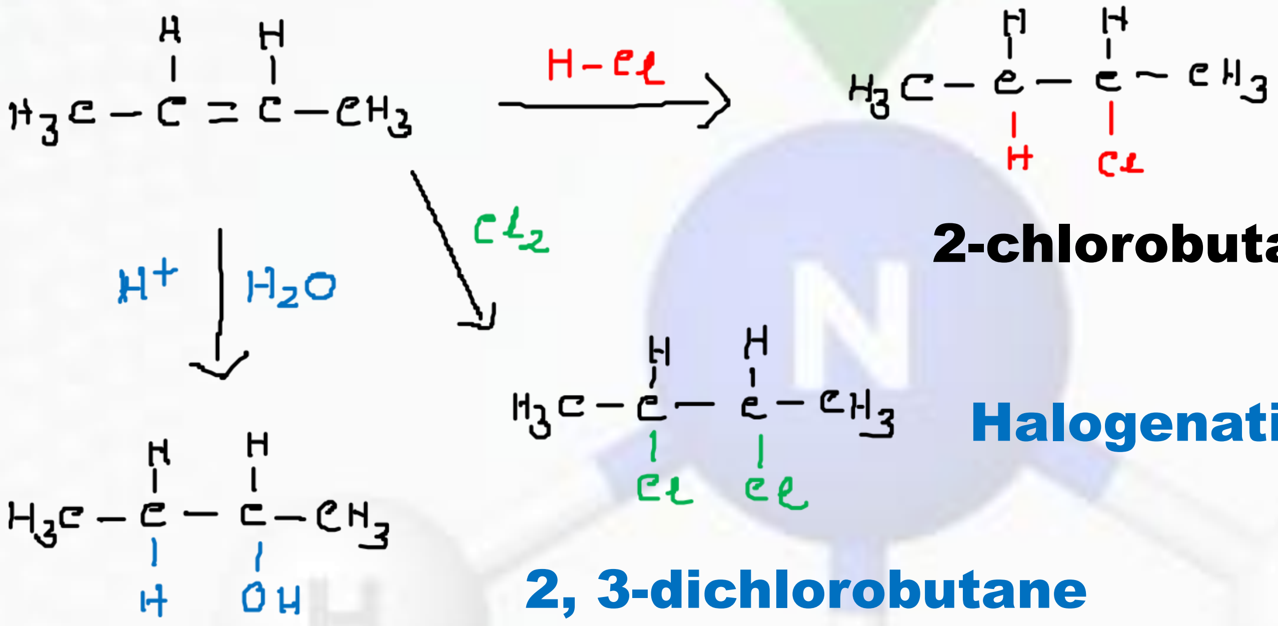
**Catalyst** Raney Ni Pd Pd/C Pt

**Hydrogenation reaction of alkenes or alkynes take place in presence of catalyst**

**These types of catalysts are called heterogenous catalyst**

# Example: Addition Reaction

## Symmetrical alkene




**Hydrohalogenation reaction**

**2-chlorobutane**

**Halogenation reaction**

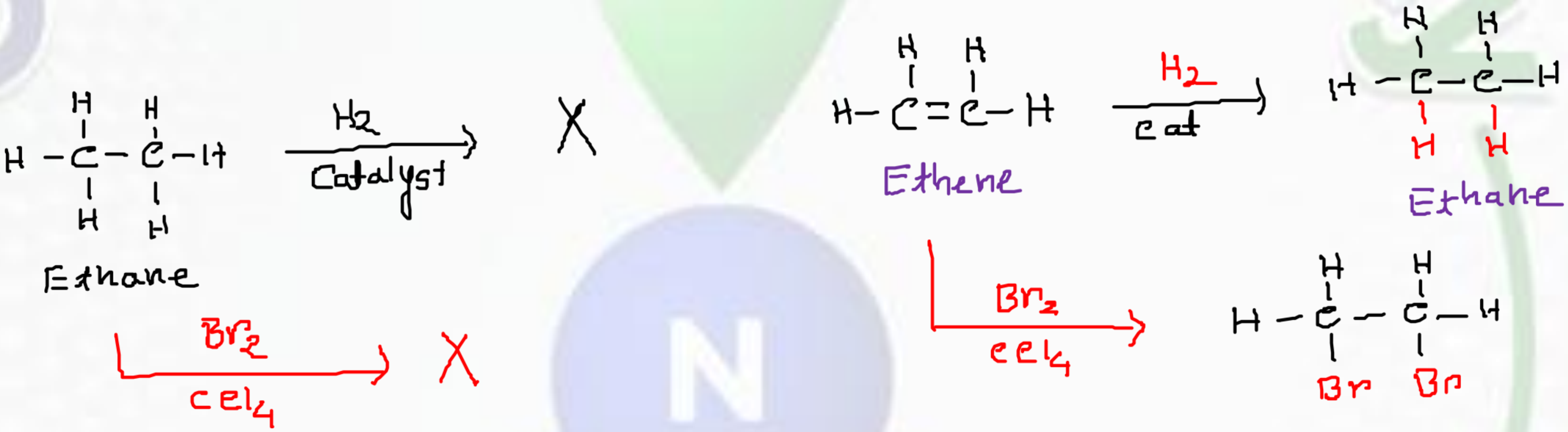
**2, 3-dichlorobutane**

**Alcohol**

**Hydration Reaction**

# Important Note:

## Alkanes cannot undergo addition reactions like alkene or alkynes




**Aromatic hydrocarbons appear unsaturated, because it contains double bonds but they have a special type of double bonds**

**Therefore, they do not undergo addition reactions like alkene**

# Test For Unsaturation

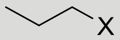
**$Br_2$, $CCl_4$ is yellow in colour, when it is added into an organic molecule which contains double bond or triple bond, yellow colour gets disappear**

**If we add yellow colour $Br_2$, $CCl_4$ solution in alkane, yellow colour won't disappear**

# Functional Groups

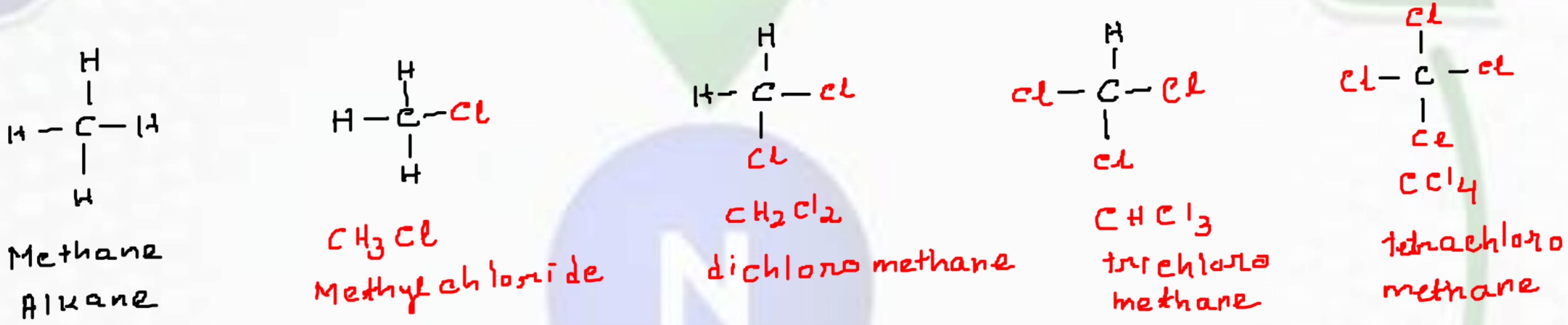
**A functional group is an atom or group of atoms within an organic molecule that has similar chemical properties whenever it appears in any organic molecules**

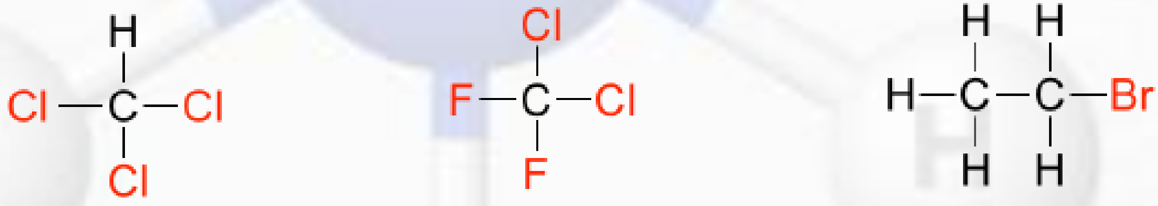
# Classification of organic compounds based on functional Groups

| Class | Functional Groups |
| --- | --- |
| Alkenes | $H_2C=C(H)-CH_3$ |
| Alkynes | H−C≡C−R |
| Alkyl halides |  X = F, Cl, Br, I |
| Alcohol | -OH |
| Ether | -O- |
| Carboxylic Acid | -COOH |
| Ester | -COOR (R = alkyl) |
| Ketone | -C=O |
| Aldehyde | -HC=O |
| Nitro | $-NO_2$ |
| Amine | $-NH_2$ |

# Haloalkane/ Alkyl halide

**When the carbon of an alkane is bonded to one or more halogens, the group is referred to as a alkyl halide or haloalkane**



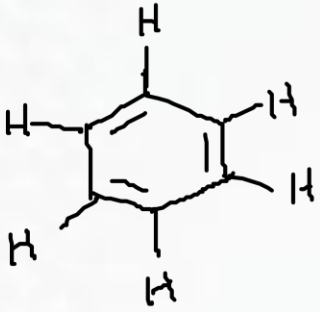



trichloromethane (chloroform)

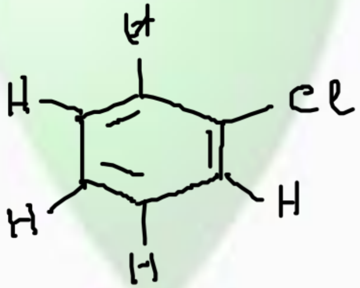
dichlorodifluoromethane (Freon-12)

bromoethane

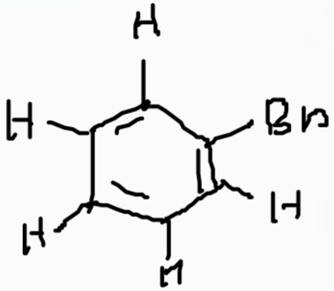
# Aryl halide (Aromatic halides)




Benzene




Aryl chloride
or
Chloro benzene




Aryl bromide
or
Bromo benzene

**Note:** **Alkyl halides or aryl halides behave differently**

# Important Reactions: Alkyl halides

**1. Alkyl halides undergo similar type of free radical reactions like alkane**

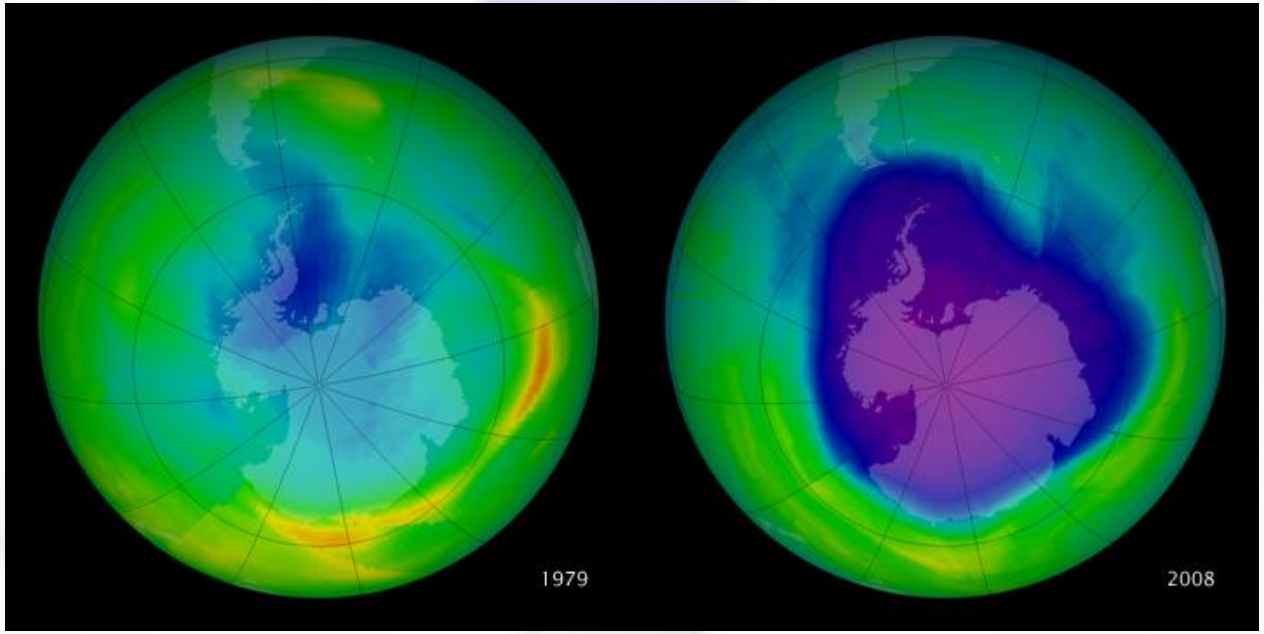
**2. Alkyl halides undergo Nucleophilic substitution**

**Aryl halides (aromatic) cannot undergo similar type free radical reactions and nucleophilic Substuituion reactions**

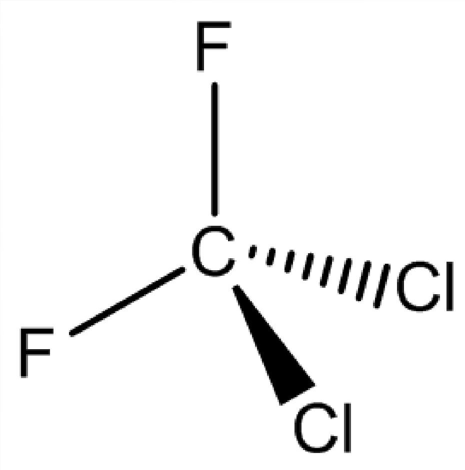
# Details reactions of alkyl halides will be discussed in haloalkane and reaction mechanism chapter

# Example: Free Radical Reaction of Alkyl halides in Environment

## Depletion of ozone layer is due to free radical reaction in Stratosphere



# CFCs is 99% responsible for ozone layer depletion

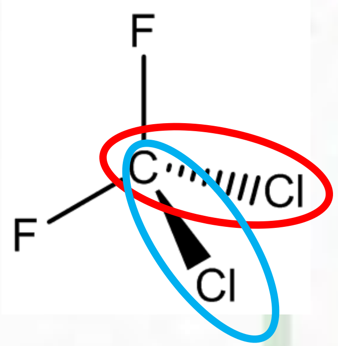



Chlorofluorocarbons

CFCs were used from the 1950s as refrigerants and in air-conditioning units, propellants in aerosol cans, solvents and to "blow" foams like polyurethane

# Why CFC was Banned?

**In 1980s, it was realized that CFCs reached the stratosphere, where in presence of UV light C-Cl bond breaks**




**Chorine radical forms**

**Chorine radical reacts with ozone and destroy ozone molecules**

**Thus UV radiation reaches to the Earth**

**Ref: HFC134 - Molecule of the Month September 2013 - HTML-only version (bris.ac.uk)**

# Now We Will Explore




# Alcohol and Phenol

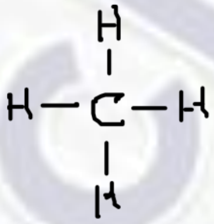
# During Covid-19 outbreak, hand sanitizers were in high demand

**For alcohol based hand sanitizers, the Food and Drug Administration (FDA) recommends a concentration of 60 to 95 % ethanol or isopropanol**

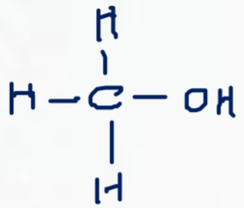
# Alcohol and Phenol

## Functional Group

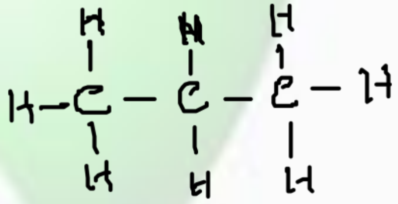
# Alcohol



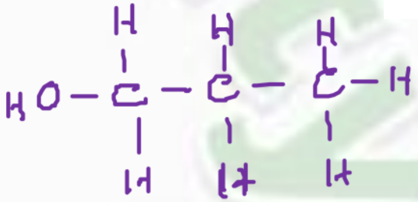
Methane



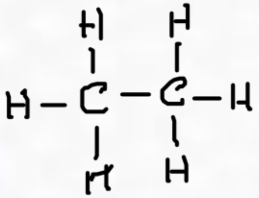
Methanol



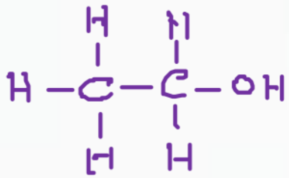
Propane



Propanol



Ethane



Ethanol

$H_3C-CH_2-CH_2-CH_3$

Butane

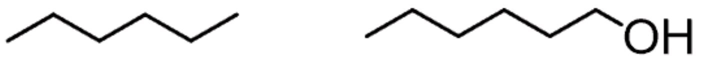
$HO-CH_2-CH_2-CH_2-CH_3$

Butanol

**The alcohol functional group involves an oxygen atom that is bonded to one hydrogen atom and one carbon atom**

# IUPAC Nomenclature of Alcohol

1. The presence of a hydroxyl is identified by changing the parent suffix from "*e*" to "*ol*"



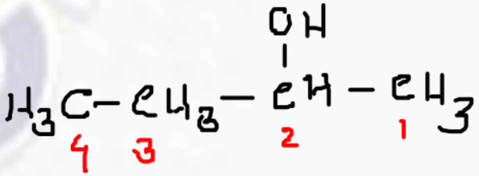

hexane hexanol

2. Choose the parent chain such that it is the longest carbon chain containing the carbon atom connected to the OH group

3. The ***hydroxyl group has a higher priority*** than alkyl substituents or π bonds. Therefore, you need to number the parent chain such that the OH gets the lowest number possible

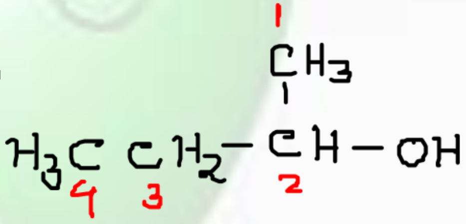
# IUPAC Nomenclature of Alcohol

1



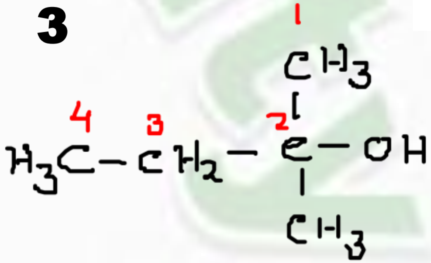
2-butanol

2



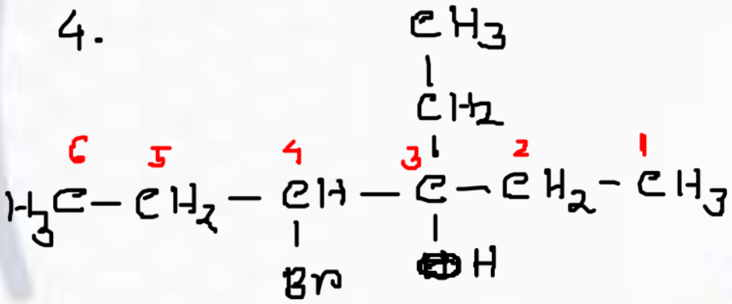
2-butanol

3



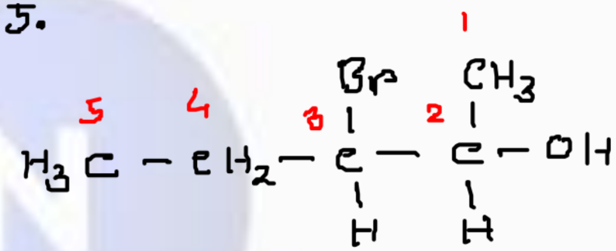
2-methyl-2-butanol

4.



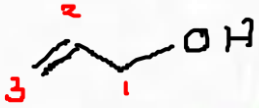
4-bromo -3-ethyl-3-hexanol

5.



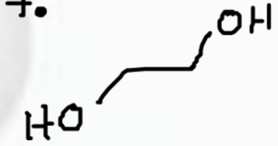
3-bromo -2-pentanol

6.



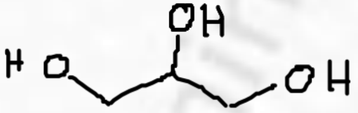
Prop-2-ene-1-ol

7.



1,2-ethanediol

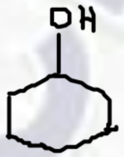
8.

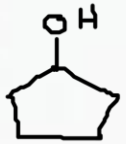


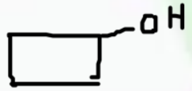
1,2,3--propanetriol

# IUPAC Nomenclature of Cyclic Alcohol

cyclopentanol

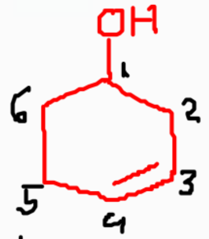


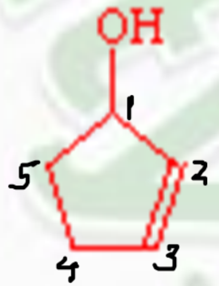




cyclohexanol

cyclobutanol

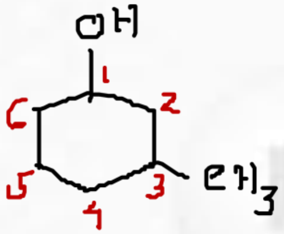



3-cyclohexen-1-ol

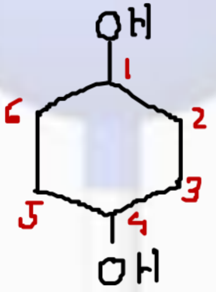



2-cyclopenten-1-ol

**When naming a cyclic alcohol, start numbering the ring beginning with the *carbon connected to the OH group***




3-methyl-1-cyclohexanol




1,4-cyclohexandiol

# Important Reactions of Alcohol

1. Oxidation reaction
2. Nucleophilic substitution like alkyl halides
3. Dehydration

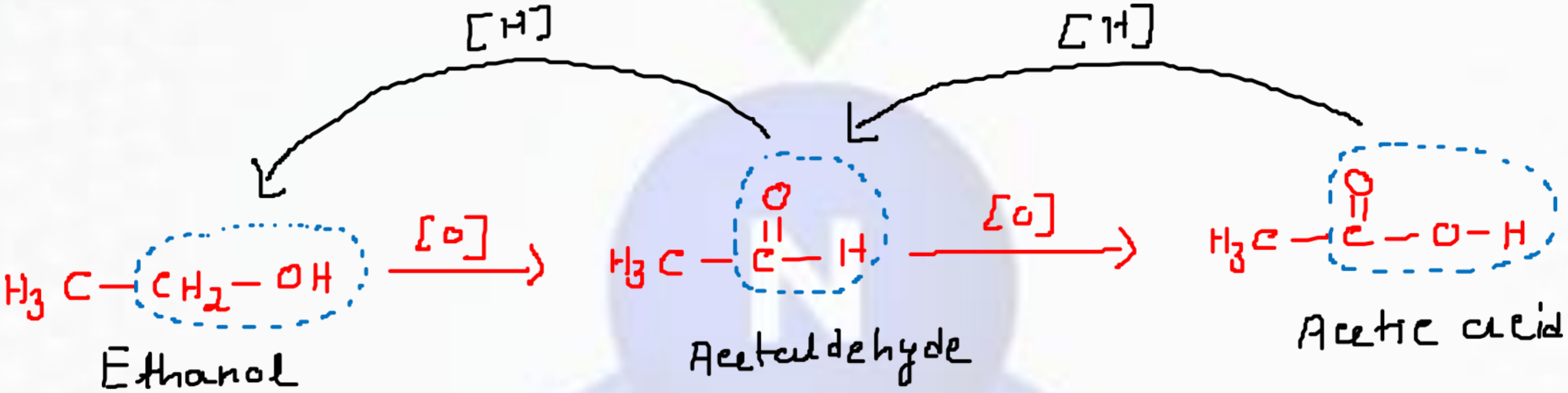
# Details reactions of alcohols will be discussed in alcohols and reaction mechanism chapter

# Let's understand
# Oxidation and Reduction Reaction

**An oxidation results in a net decrease in the number of C-H bonds, or a net increase in the number of C-O bonds (or equivalent)**

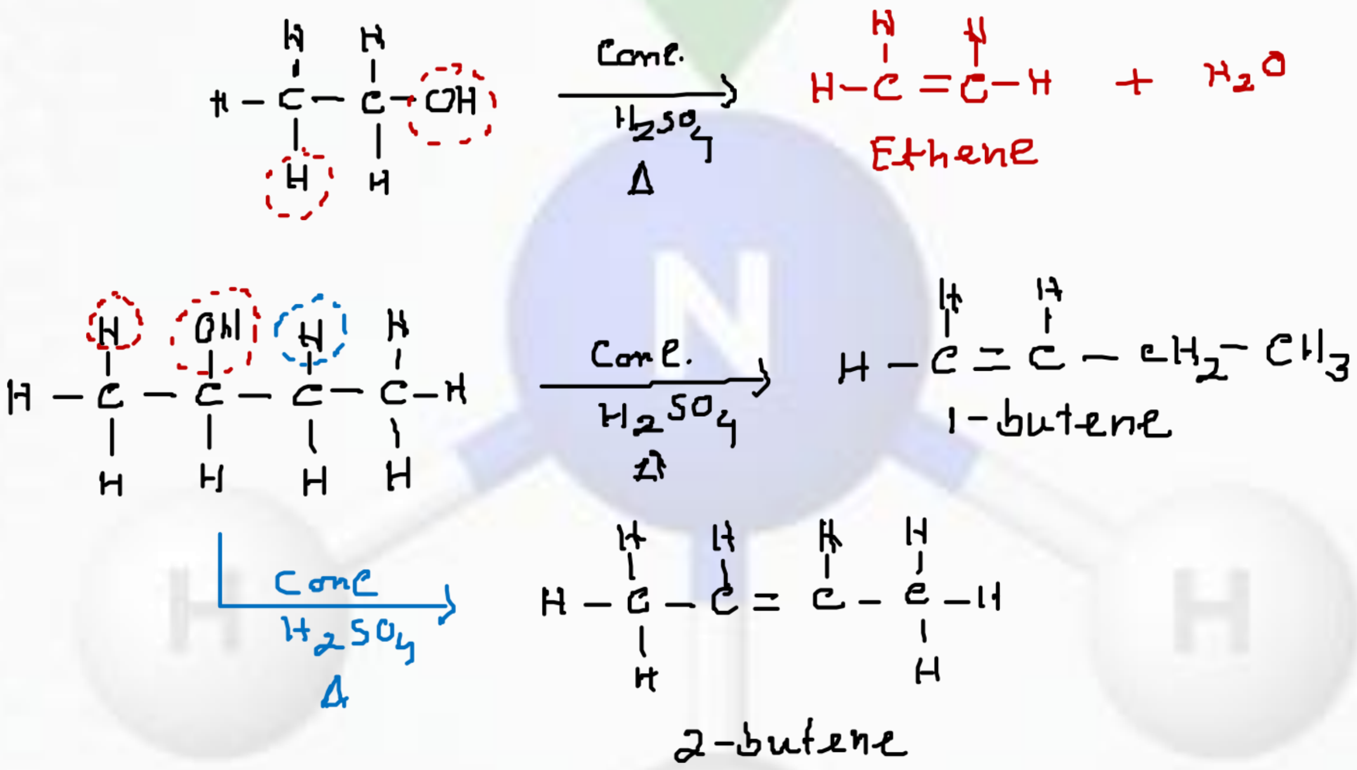
**A reduction results in a net increase in the number of C-H bonds, or a net decrease in the number of C-O bonds (or equivalent, such as C-Cl, C-Br, etc)**

# Oxidation and Reduction Reaction



# Dehydration of Alcohols

**Ethanol gives ethene and water when it is heated with concentrated sulphuric acid**



# Preparation of Ethanol

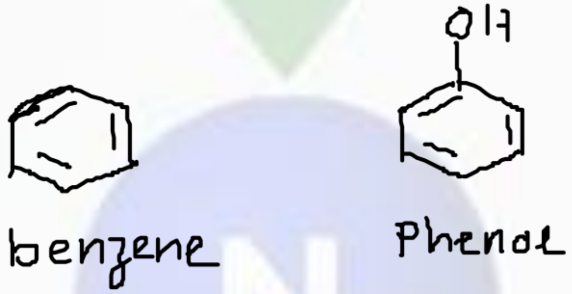
## Ethanol can be produced when sugar solutions are fermented using yeast

| Glucose | $\xrightarrow{\text{yeast}}$ | Ethanol | + Carbon di oxide |
|---|---|---|---|
| $C_6H_{12}O_6$ | | $CH_3CH_2OH$ | $CO_2$ |

**Fermentation method is used to prepare alcoholic drinks. Fruit juices, such as grape juice, is a source of glucose ($C_6H_{12}O_6$). When yeast is added into it, in the absence of oxygen wine (a solution of ethanol) and carbon dioxide generate**

# Phenol

**When OH group is attached with benzene ring is called phenol**




**Alcoholic OH and phenolic OH behaves differently**

**Ex: Phenolic OH is acidic in nature and alcoholic OH does not behaves as acid**

# Phenol: Uses and Application

**Phenol is also known as carbolic acid**

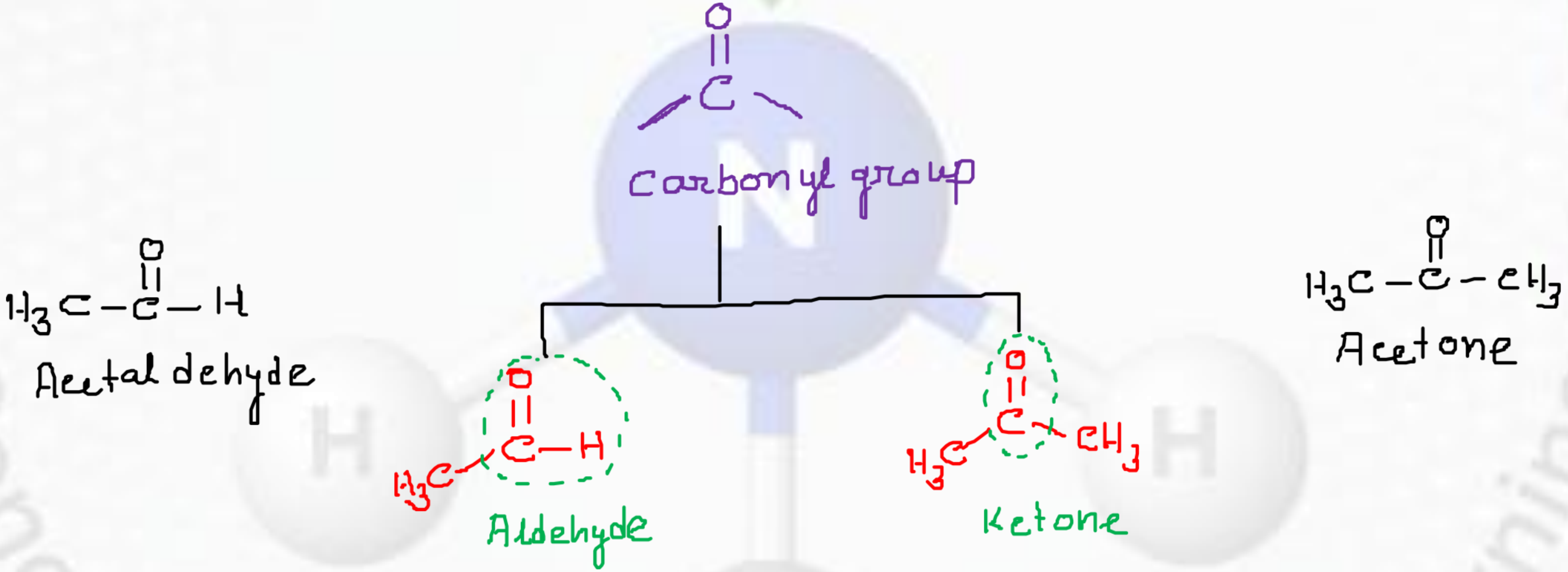
**This chemical was one of the first antiseptics used to sterilize medical equipment, but can also be mixed with other ingredients to clean toilets, floors, drains, and other items**

# Carbonyl

## Functional Group

# Carbonyl Group: Aldehyde and Ketone

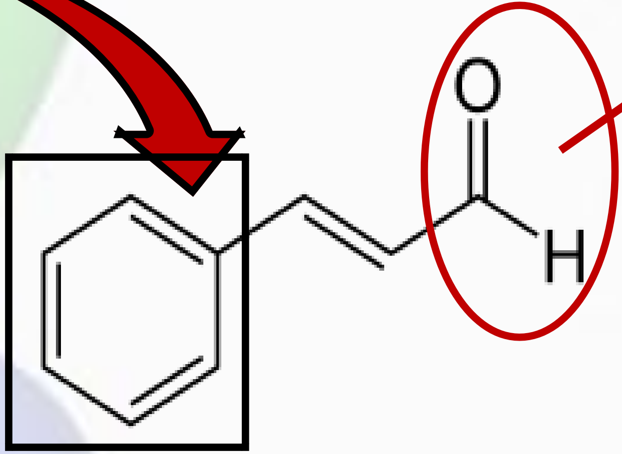
**Carbonyl group contains a carbon atom and an oxygen atom which is connected via a double bond**



CINNAMON

FLAVOUR

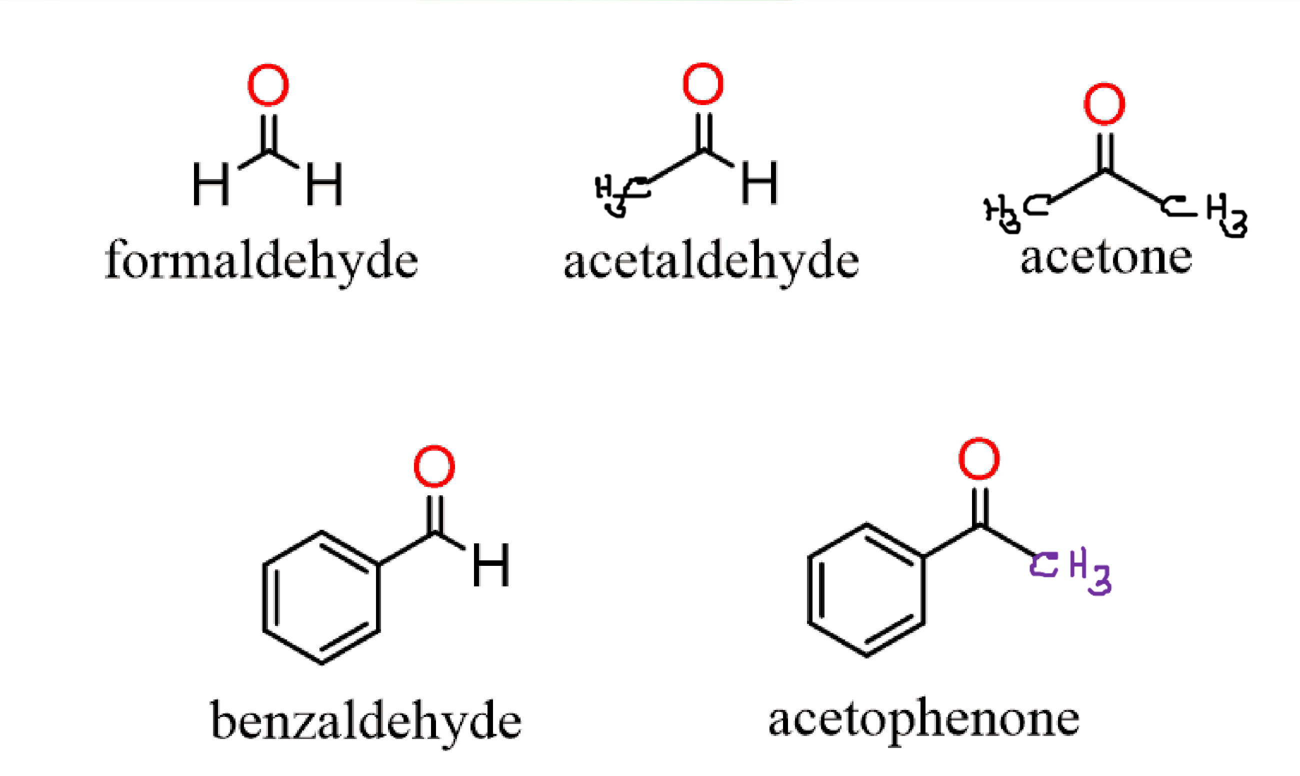
ALDEHYDE FUNCTIONAL GROUP




CINNAMALDEHYDE

**AROMATIC COMPOUND BECAUSE IT CONTAINS PHENYL RING**

# Common Names of Ketone and Aldehyde

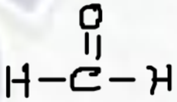


# IUPAC Nomenclature of Aldehydes

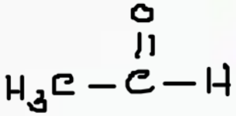
**Aldehydes and ketones have higher priority than all the other functional groups which we covered so far like double bond, triple bond, and alcohol. Therefore, they define the parent chain and give the corresponding *suffix***

https://www.chemistrysteps.com/nomenclature-of-aldehydes-and-ketones/

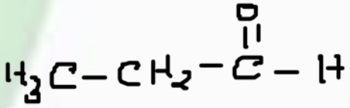
# IUPAC Nomenclature of Aldehydes



**Methanal**



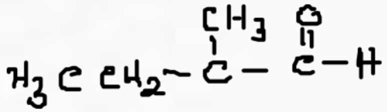
**Ethanal**



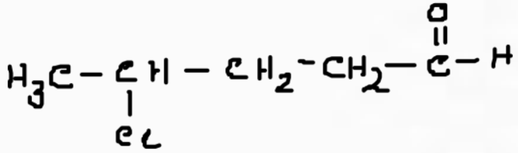
**Propanal**

**Benzaldehyde**

**Aromatic aldehyde**



**2-methylbutanal**



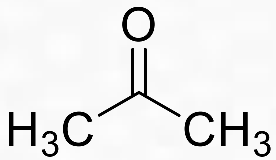
**4-chlorolpentanal**

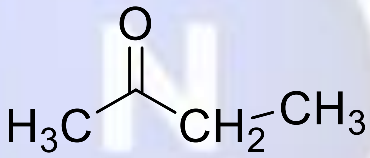
# IUPAC Nomenclature of Ketones

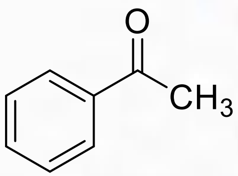
$H_3C-CH_2-CH_3$
Propane

$H_3C-\overset{O}{\overset{\|}{C}}-CH_3$
Propanone

**Drop the "e" change suffix to "one"**



# Ether

## Functional Group

# Ether

**In an ether functional group, a central oxygen is bonded to two carbons**

$H_3C-O-CH_3$

**Dimethyl ether**

$H_3CH_2C-O-CH_2\ CH_3$

**Diethyl ether**

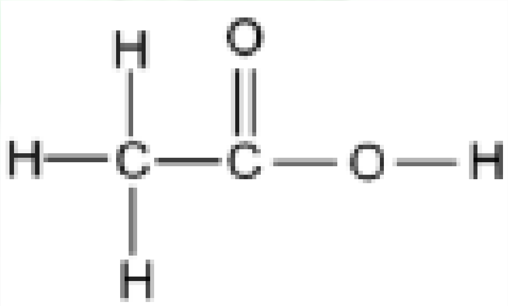
**Ethers are used as solvents for organic reactions**

**Di ethyl ether is used as an inhalable anesthetic**

# Carboxylic Acid

## Functional Group

# Acetic acid

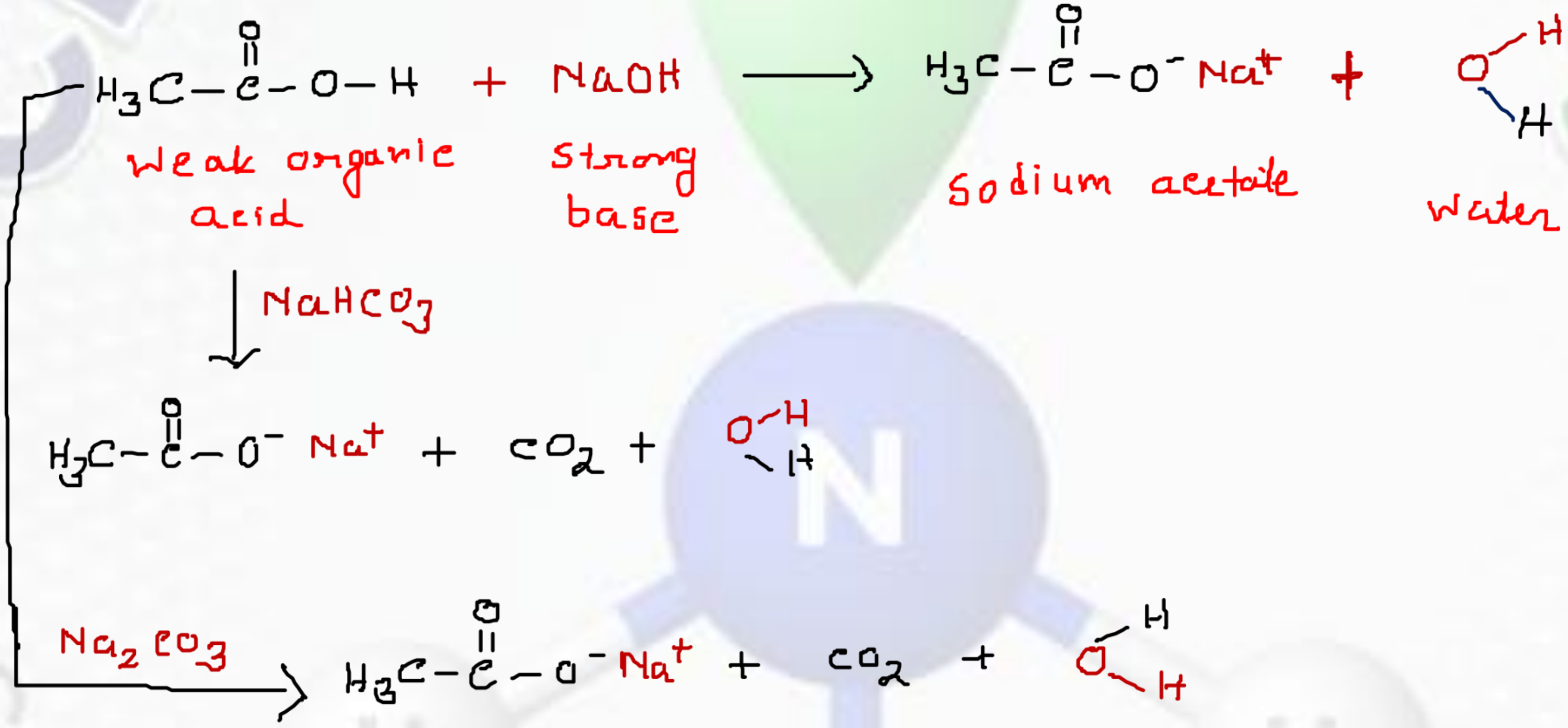



**Ethanoic acid is a colorless liquid**

**5% to 8% solution of acetic acid in water is known as vinegar. Vinegar is used as preservative in pickles**

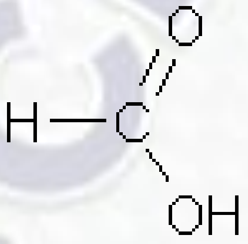
**Carboxylic acids are weak acid compared to mineral acids**

# Reaction of Acetic acid



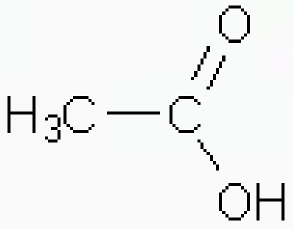

**Example of acid-base reaction**

# IUPAC Nomenclature Carboxylic Acids



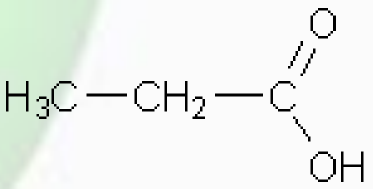
**Formic acid (Methanoic acid)**

**From ants**



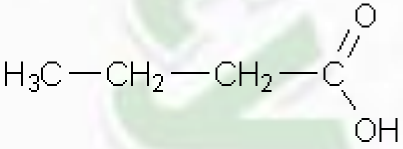
**Acetic acid (Ethanoic acid)**

**From Vinegar**



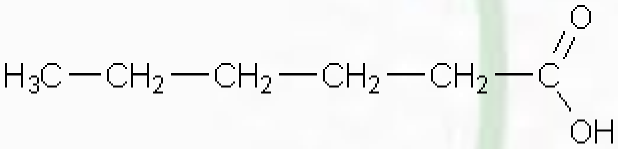
**Propionic acid**

**From milk products**



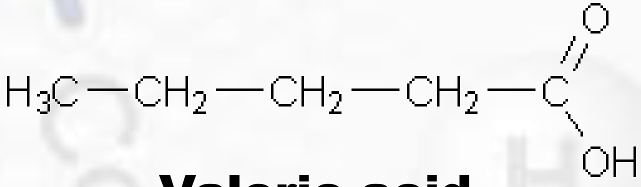
**Butanoic acid**

**From butter**



**Caproic acid, hexanoic acid**

**Goat's milk**



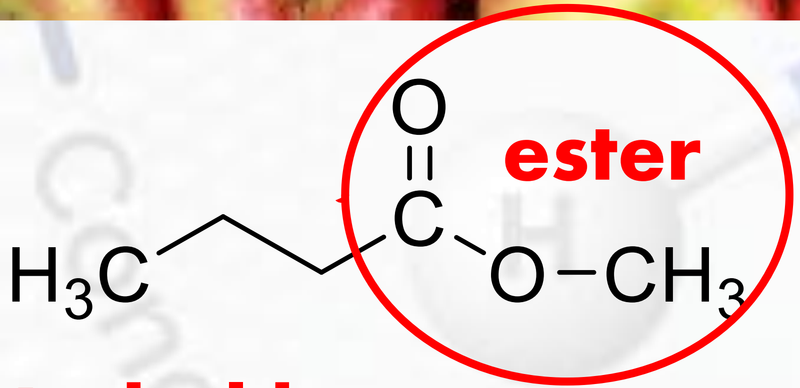
**Valeric acid, pentanoic acid**

**valerian roots**

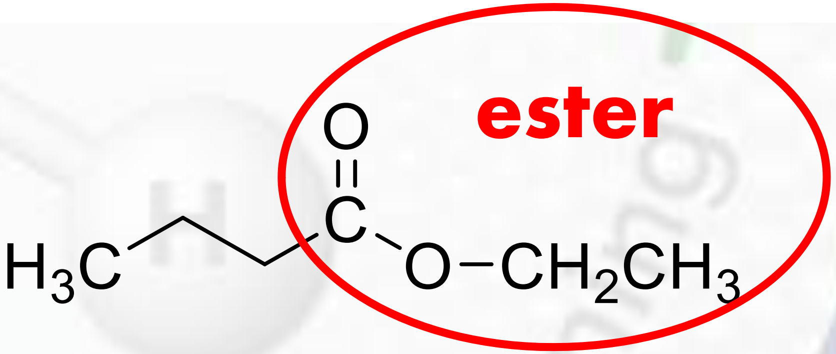
# Ester

## Functional Group






**Methyl butanoate**



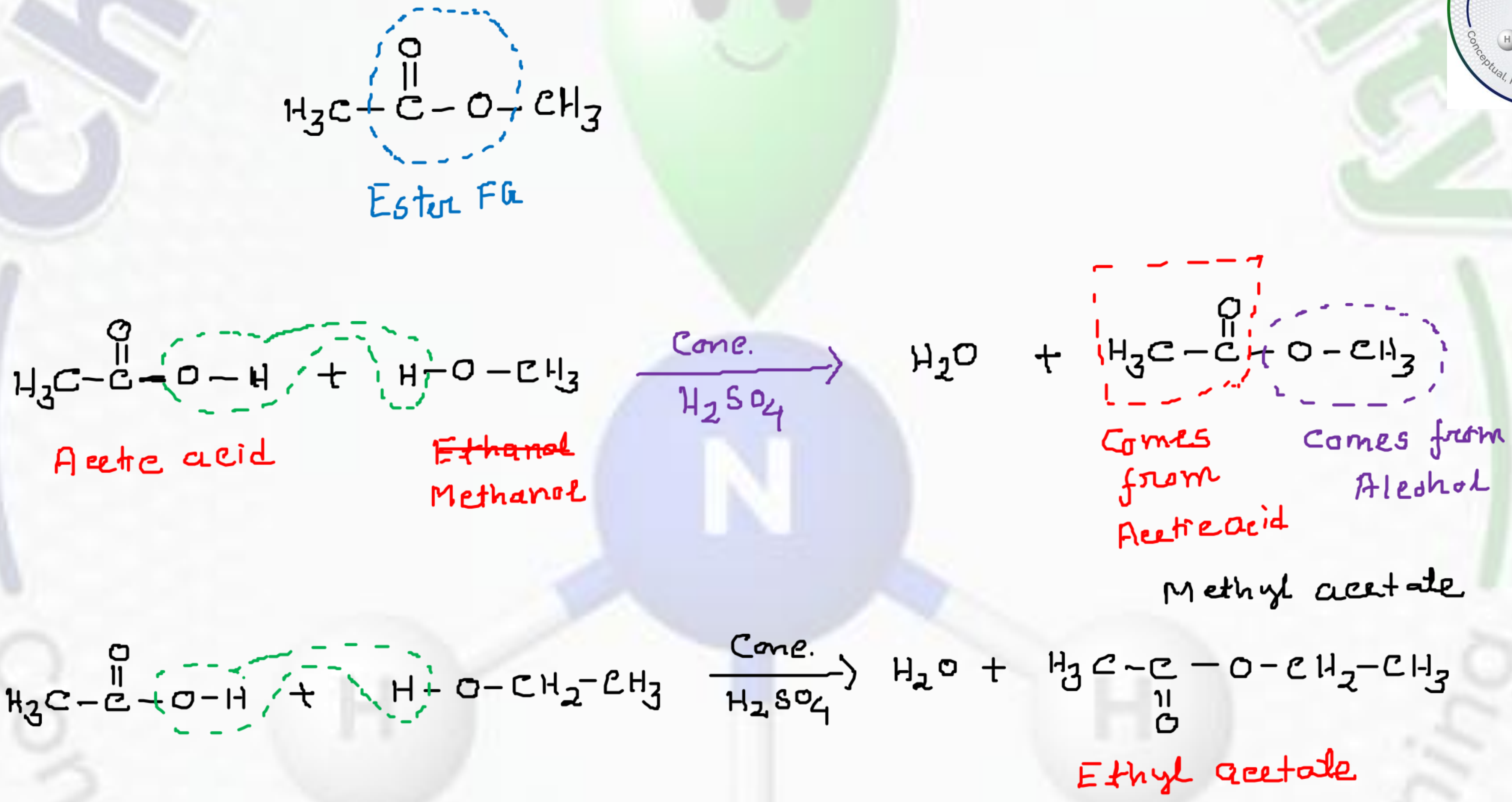

**Ethyl butanoate**

# Other

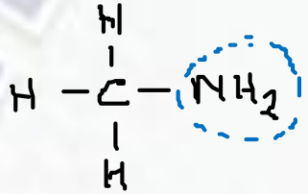
# Important

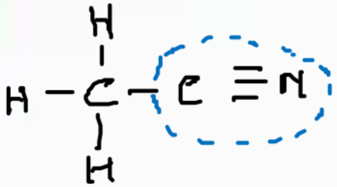
# Functional Groups

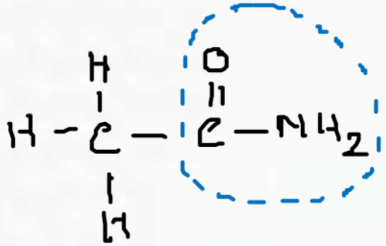
# Ester: Functional Group

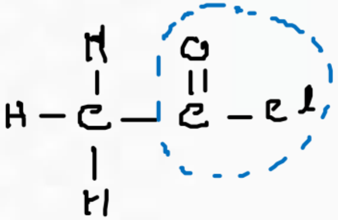


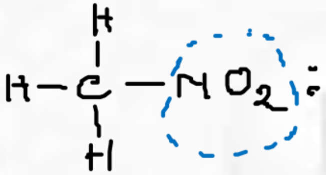
# Other Functional Groups: Aliphatic


: Amine

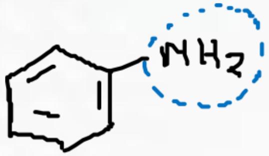

: Nitrile

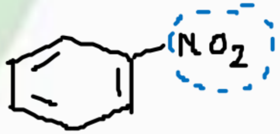

: Amide

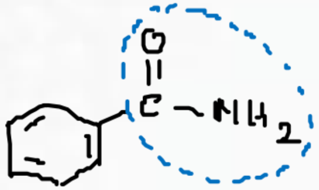

: Acid chloride

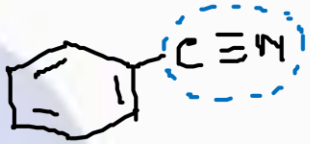

: Nitro

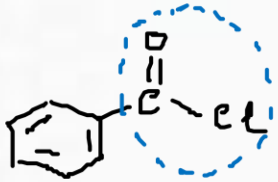
# Other Functional Groups: Aromatic


: Aniline


: Nitro benzene


: Benzamide


: Benzo nitrile


: Benzoyl chloride