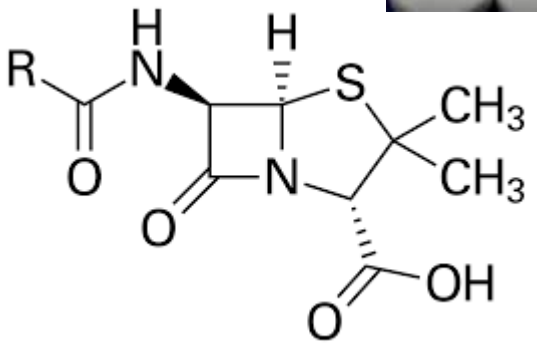
Chapter 1: Functional Groups in Organic Chemistry







By Ayele W.

What is organic chemistry?

- Organic chemistry is the study of the chemistry of **carbon** compounds.
- The compounds of carbon are the central substances of which **all living things** on this planet are made.

- Every **living organism** is made of organic chemicals.
  - ✓The proteins that make up your hair, skin, and muscles;
  - ✓the DNA that controls your genetic heritage;
  - ✓ the foods that nourish you; and
  - ✓The medicines that heal you are all organic chemicals.

Functional groups

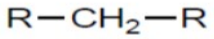
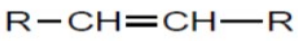
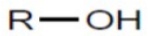
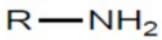
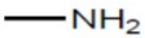
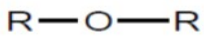
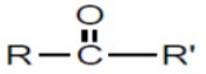
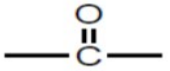
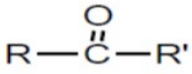
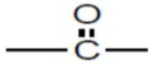
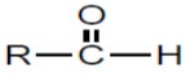
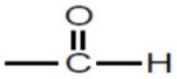
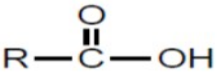
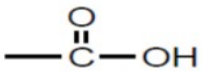
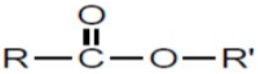
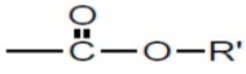
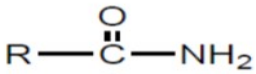
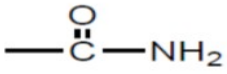
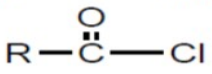
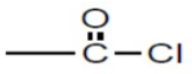
- Chemistry of organic compounds is determined by **functional groups**.
- Functional group is an atom or group of atoms within a molecule that shows a characteristic set of predictable **physical** and **chemical behaviours** of molecules.

- They are a particular combination of atoms in a molecule, which undergo a characteristic pattern of reactivity i.e. the reactive part of a molecule

Cont’d

- Therefore, we do not have to study the chemical reactions of even a fraction of the 10 million known organic compounds.

- Instead, we need to identify only a few characteristic functional groups and then study the chemical reactions that each undergoes.
- Functional groups are also important because they are the units by which we divide organic compounds into families of compounds.

Organic Compound	General formula	Functional Group
Alkane		
Alkene		
Alkene		
Alcohol		
Amine		
Ether		
Carbonyl compound		
Ketone		
Aldehyde		
Carboxylic acid		
Ester		
Amide		
Acyl halide		
Alkyl halide		

cont’d

- Organic compounds having only C-C and C-H bonds are called **Hydrocarbons**.

- Hydrocarbons are compounds that contain only **carbon** and **hydrogen**
- There are four families that contain molecules made of only carbon and hydrogen.
- Hydrocarbons
  - ✓ Alkanes
  - ✓ Alkenes
  - ✓ Alkynes

  } **aliphatic** hydrocarbons

  - ✓ **Aromatics**

Nomenclature of Alkanes

- There are two types of naming system commonly used in organic chemistry.

1. Trivial (common):

- ✓ based on some property or historical aspect or source of the compounds.
- ✓ The name tells you little about the structure of the compound.

2. Systematic (IUPAC): Beginning in 1892, chemists developed a set of rules for naming organic compounds based on their structures

Cont’d

- Example:

Trivial name	Systematic name	Example(s)
• Paraffin	alkane	methane, butane
• Olefin	alkene	ethene, butene
• Fatty acid	carboxylic acid	ethanoic acid

IUPAC Nomenclature of Unbranched Alkane

- The IUPAC method for naming a straight chain or unbranched alkane is as follows:

- **Step 1**:Start with the prefix that indicates the **number of carbons** in the compound.

- The prefix for 8 carbons is **oct –**.

$CH_3CH_2CH_2CH_2CH_2CH_2CH_2CH_3$

Step 2: Add the –ane ending = Octane

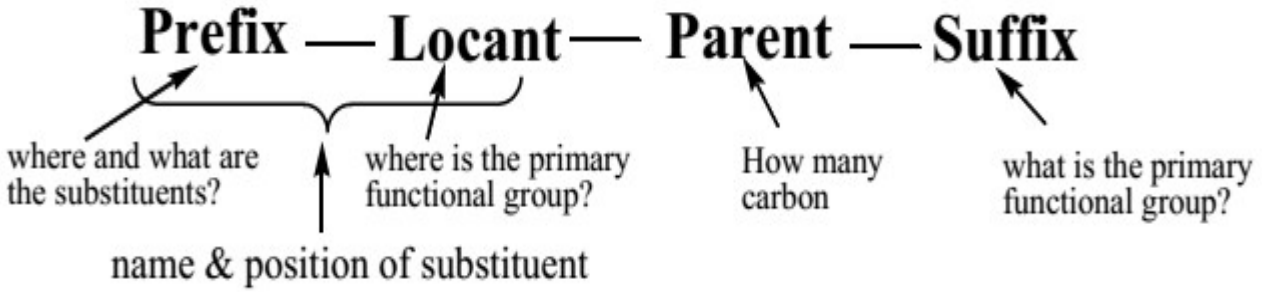
- The suffix –ane indicate alkane functional group.

Naming a straight chain alkanes

Molecular Formula	Structural Formula	IUPAC Name	Molecular Formula	Structural Formula	IUPAC Name
CH_4	CH_4	Methane	$C_{11}H_{24}$	CH_3-$(CH_2)_9$-CH_3	Undecane
C_2H_6	CH_3-CH_3	Ethane	$C_{12}H_{26}$	CH_3-$(CH_2)_{10}$-CH_3	Dodecane
C_3H_8	CH_3-CH_2-CH_3	Propane	$C_{13}H_{28}$	CH_3-$(CH_2)_{11}$-CH_3	Tridecane
C_4H_{10}	CH_3-$(CH_2)_2$-CH_3	Butane	$C_{14}H_{30}$	CH_3-$(CH_2)_{12}$-CH_3	Tetradecane
C_5H_{12}	CH_3-$(CH_2)_3$-CH_3	Pentane	$C_{15}H_{32}$	CH_3-$(CH_2)_{13}$-CH_3	Pentadecane
C_6H_{14}	CH_3-$(CH_2)_4$-CH_3	Hexane	$C_{20}H_{42}$	CH_3-$(CH_{18}$-CH_3	Icosane
C_7H_{16}	CH_3-$(CH_2)_5$-CH_3	Heptane	$C_{30}H_{62}$		Triacontane
C_8H_{18}	CH_3-$(CH_2)_6$-CH_3	Octane	$C_{40}H_{82}$		Tetracontane
C_9H_{20}	CH_3-$(CH_2)_7$-CH_3	Nonane	$C_{50}H_{102}$		Tentacontane
$C_{10}H_{22}$	CH_3-$(CH_2)_8$-CH_3	Decane	$C_{100}H_{202}$		Hectane

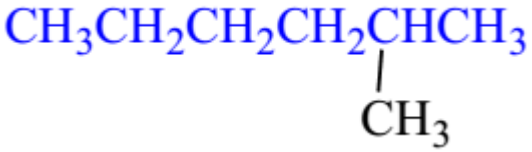
IUPAC Nomenclature of Branched Alkanes

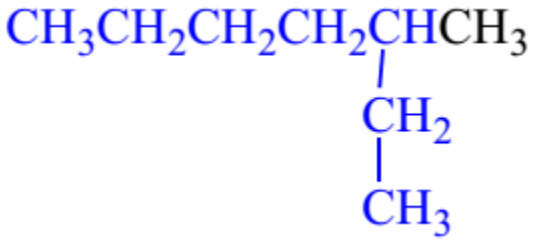
- The IUPAC name typically has three major parts: prefix, parent, and suffix.



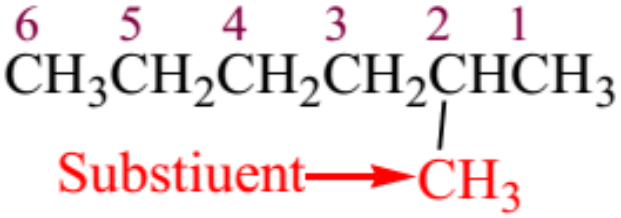
It involves the following steps

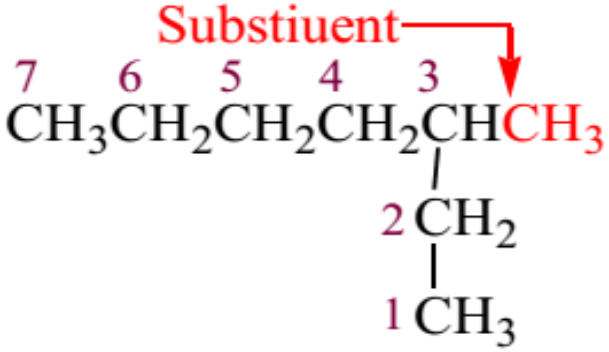
1. Locate the longest continuous chain of carbon atoms; this chain determines the parent name for the alkane.





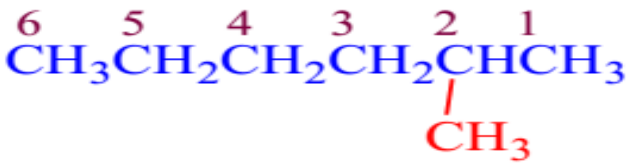
2. Number the longest chain beginning with the end of the chain nearest the substituent



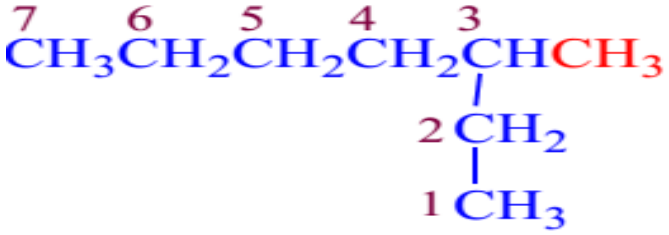


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3. Use the numbers obtained by application of rule 2 to designate the location of the substituent group.



2-Methylhexane

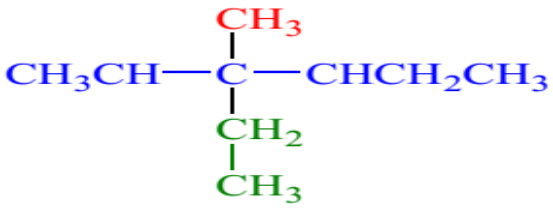


3-Methylheptane

- The parent name is placed last; the substituent group, preceded by the number indicating its location on the chain, is placed first.

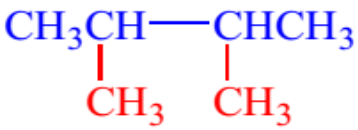
.

5. When two substituents are present on the same carbon, use the number twice.

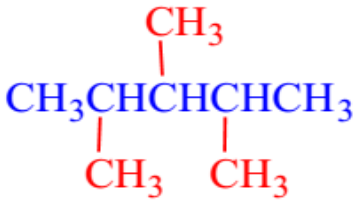


3-Ethyl-3-methylhexane

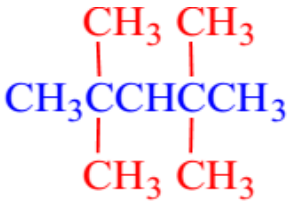
6. When two or more substituents are identical, indicate this by the use of the prefixes di-, tri-, tetra-, and so on.



2,3-Dimethylbutane



2,3,4-Trimethylpentane



2,2,4,4-Tetramethylpentane

7. When branching first occurs at an equal distance from either end of the longest chain, choose the name that gives the lower number at the first point of difference.

ALKYL GROUPS (R)

- **Alkyl groups or radicals** are formed by removing one H atom from the corresponding alkanes.
- A methyl group (CH_3-) is an alkyl group derived from methane (CH_4).

- Unbranched alkyl groups in which the point of attachment is at the end of the chain are named in IUPAC nomenclature by replacing th

IUPAC name = alkane –ane + ly= **Alkyl**

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- The symbol R is used to represent a general alkyl group (i.e. a methyl, ethyl, propyl, etc. group).

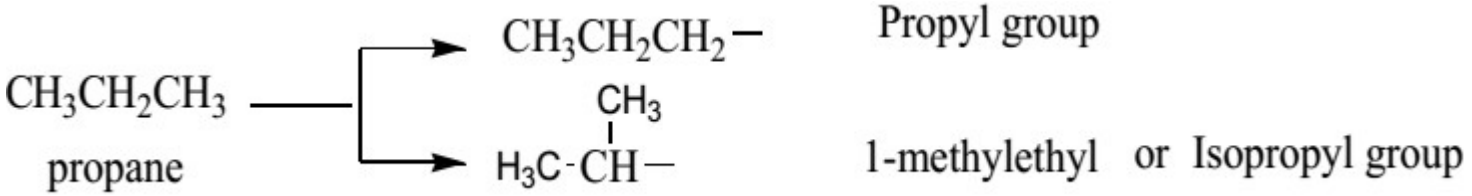
- When a hydrogen atom is removed from a benzene ring, this is a phenyl group.

- The symbol Ph is used to represent this groups.

Common and IUPAC Nomenclature of Branched Alkyl Groups

- Branched alkyl groups are named by using the longest continuous chain that begins at the point of attachment as the base name

1. Three-Carbon Groups

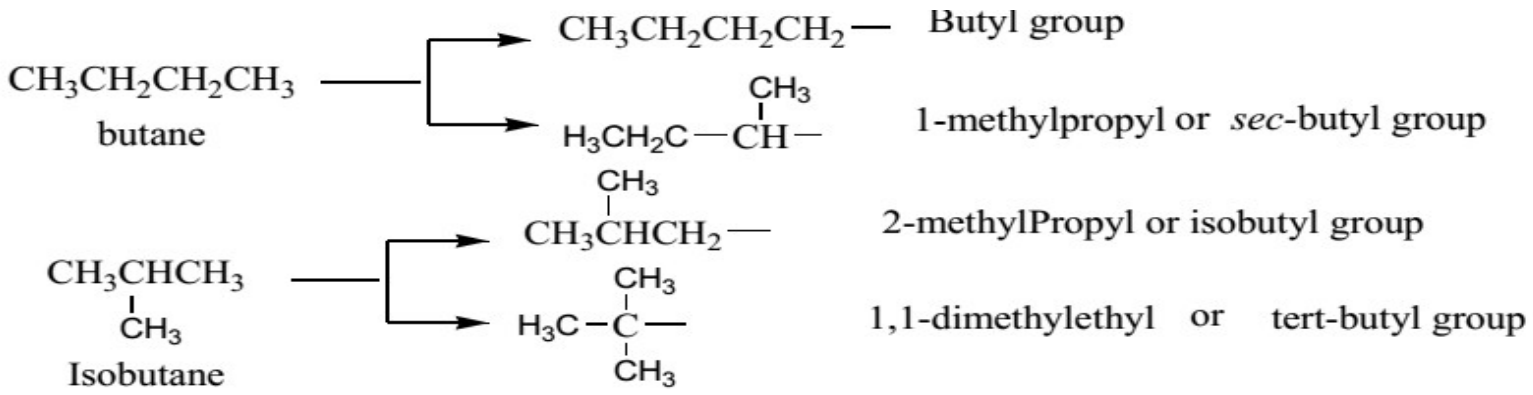


- 1-Methylethyl is the systematic name; isopropyl is a common name.

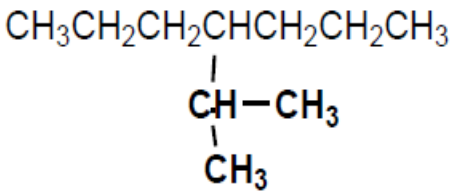
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- Notice to remember the following common naming for alkyl groups
  - **n-alkyl** is alkyl groups with no branching.
  - **Iso-alkyl** is alkyl group with one branch in the 2nd carbon.
  - **Neo-alkyl** is alkyl group with two branches in the 2nd carbon (two methyl group in the 2nd carbon).

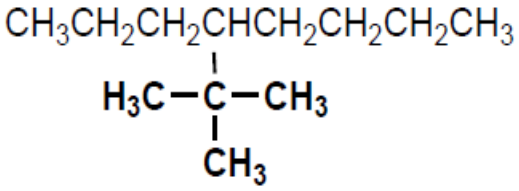
2. Four-Carbon Groups



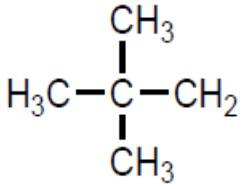
- The common names **isopropyl**, **isobutyl**, ***sec*-butyl**, ***tert*-butyl** are **approved** by the **IUPAC** for the unsubstituted groups.



4-(1-Methylethyl)heptane or
4-isopropylheptane

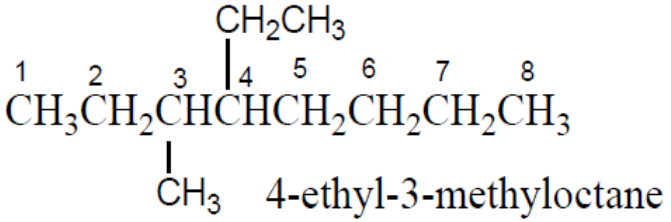
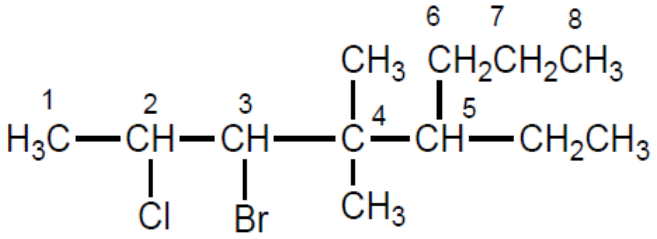


4-(1,1-Dimethylethyl)octane or
4-tert-butyloctane



2,2-Dimethylpropyl or
neopentyl group

• IUPAC Names of Highly Branched Alkanes

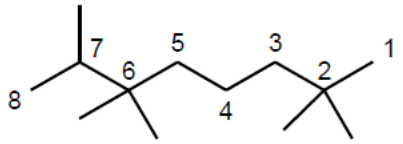
Example:		
	 4-ethyl-3-methyloctane	 3-bromo-2-chloro-5-ethyl-4,4-dimethyloctane

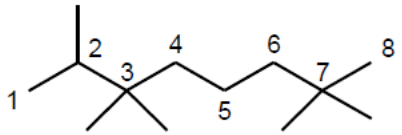
- The compound becomes an octane derivative that bears a C-3 methyl group and a C-4 ethyl group.

- When two or more different substituents are present, they are listed in **alphabetical order** in the name.

- The IUPAC name for this compound is **4-ethyl-3-methyloctane**

- Italicized prefixes such as sec- and tert- are ignored when alphabetizing except when they are compared with each other.
- *Tert*-Butyl precedes isobutyl, and *sec*-butyl precedes *tert*-butyl.
- A





that concerns the direction of numbering is the ***first***

2,**2**,6,6,7-pentamethyloctane
(Correct)

2,**3**,3,7,7-pentamethyloctane
(Incorrect)

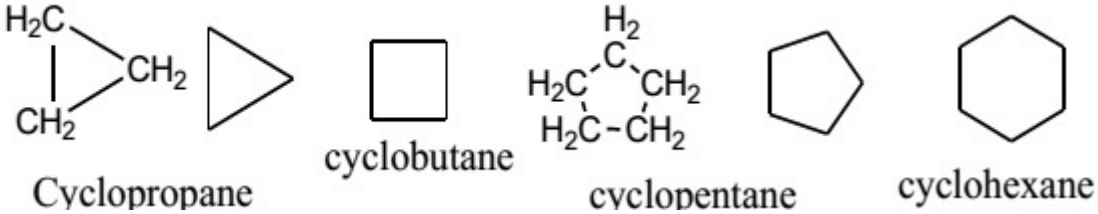
- When deciding on the proper direction, a point of difference occurs when one order gives a lower locant than another.
- Thus, although 2 is the first locant in both numbering schemes, the tie is broken at the second locant, and the rule favors 2,**2**,6,6,7, which has 2 as its second locant, whereas 3 is the second locant in 2,**3**,3,7,7.
- Notice that locants are not added together, but examined one by one.

- Finally, when equal locants are generated from two different numbering directions, choose the direction that gives the **lower number** to the substituent that appears first in the name. (Remember, substituents are listed alphabetically.)

Cycloalkane Nomenclature

- **Cycloalkanes** are alkanes that contain a ring of three or more carbons.
- Are characterized by the molecular formula C_nH_{2n}.
- Named by adding the prefix **cyclo-** to the name of the **unbranched** alkane with the same number of carbons as the ring.

Examples of cycloalkanes

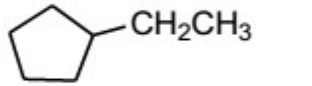


Cyclopropane cyclobutane cyclopentane cyclohexane

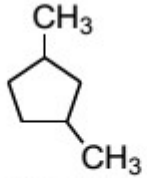
Cont'd

- Substituent groups are identified in the **usual way**.
- Choose a point of attachment at C-1 and number the ring in the direction that gives the lowest number to the substituents at

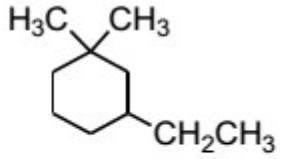
Example:



Ethylcyclopentane



1,3 dimethylcyclopentane

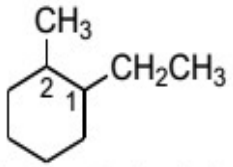


3-Ethyl-1,1-dimethylcyclohexane

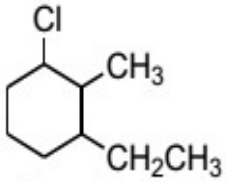
not 1-Ethyl-3,3-dimethylcyclohexane

Cont'd

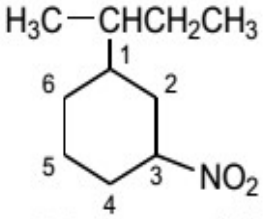
- For different alkyl groups, number them by



1-Ethyl-2-methylcyclohexane
not 2-Ethyl-1-methylcyclohexane

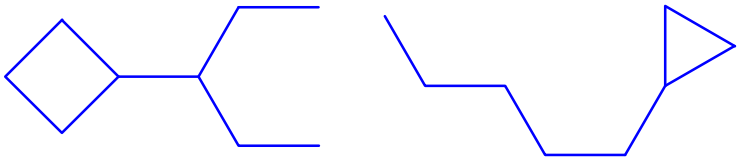


1-chloro-3-ethyl-2-methylcyclohexane



1-*sec*-butyl-3-nitrocyclohexane

- When the ring contains fewer carbon atoms than an alkyl group attached to it, named as an **alkane**, and the ring is treated as a **cycloalkyl substituent**.
- Example



3-Cyclobutylpentane

1-cyclopropylpentane

Physical Properties of Alkanes

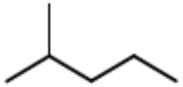
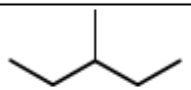
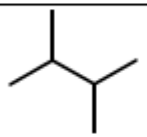
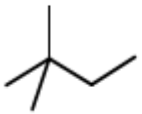
- All alkanes have **similar chemical properties** but their physical properties vary with molecular weight, chemical bonds (van der Waals forces) and the shape of the molecule.

Alkane	Boiling point (°C)	Melting point(°C)
CH_4	-164	-182.5
C_2H_6	-88.6	-183.3
C_3H_8	-42.1	-189.7
C_4H_{10}	-0.6	-138.4

- All the alkanes with four carbons or less are gases at room temperature and atmospheric pressure

Cont'd

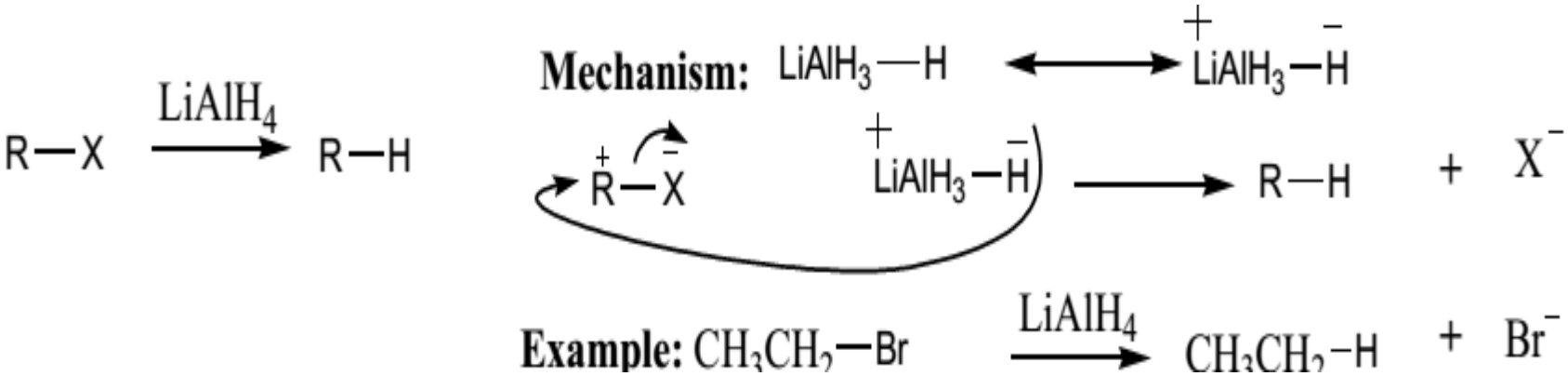
- C1-C4 are gases, C5-C17 are liquids and greater than C17 are solids.

Molecular Formula	Bond-Line Formula	M pt. (°C)	B pt. (°C) (1 atm)	Density (g /mL) at 20°C	Index of Refraction (*n*D 20°C)
C_6H_{14}		-95	68.7	0.6594	1.3748
C_6H_{14}		-153.7	60.3	0.6532	1.3714
C_6H_{14}		-118	63.3	0.6643	1.3765
C_6H_{14}		-128.8	58	0.6616	1.3750
C_6H_{14}		-98	49.7	0.6492	1.3688

- These are **insoluble** in water as they are **nonpolar** compounds but
- soluble in **organic solvents** like ether, benzene and acetone etc. Liquid alkanes are lighter than water.

Preparation of Alkanes

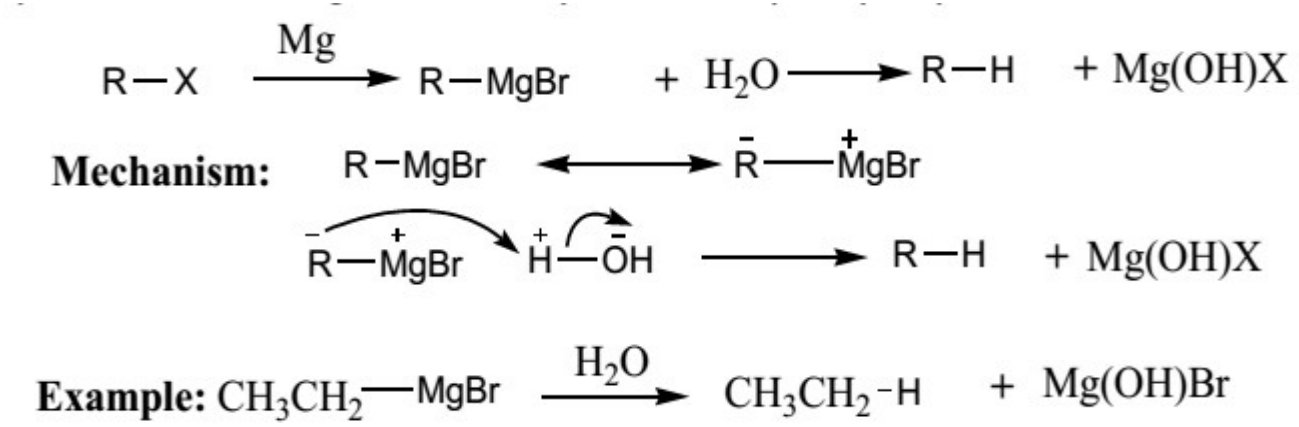
1) Reduction of Alkyl halides (by $LiAlH_4$ or Zn in acetic acid)



- **Reaction mechanism** depicts bond breakage and bond formation as reactants are converted into products.

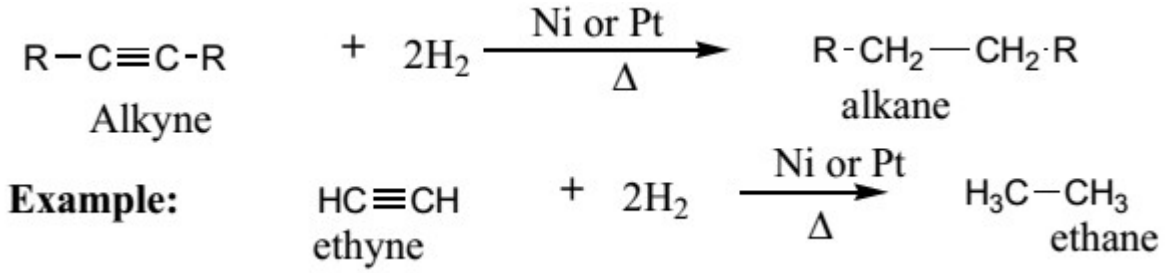
Cont'd

2) From Grignard Reagent (RMgBr):



Cont'd

3) By Hydrogenation of Alkynes and alkenes with metal catalyst (Pt, Pd or Ni) at 200-300^{o}C.



4) **Wurtz Reaction**: Higher alkanes are produced by heating an alkyl halide with sodium metal in dry ether solution.

- Two molecules of alkyl halide (RX) condense with sodium : $2R\text{-}X + 2Na \rightarrow \mathbf{R\text{-}R} + 2NaX$ etrical alkane (R-R).

Cont'd

- This method is useful only for the **preparation of symmetrical alkanes**.

$$2R\text{-}X + 2Na \rightarrow \mathbf{R\text{-}R} + 2NaX$$

5) Decarboxylation of Carboxylic acids: Heating sodium salt of organic acid with soda lime (mixture of NaOH and CaO) decarboxylate to give alkane.

$$RCOONa + 2\ NaOH + CaO + heat \rightarrow \mathbf{R\text{-}H} + Na_2CO_3\ (S)$$

Cont’d

Chemical Properties Alkanes

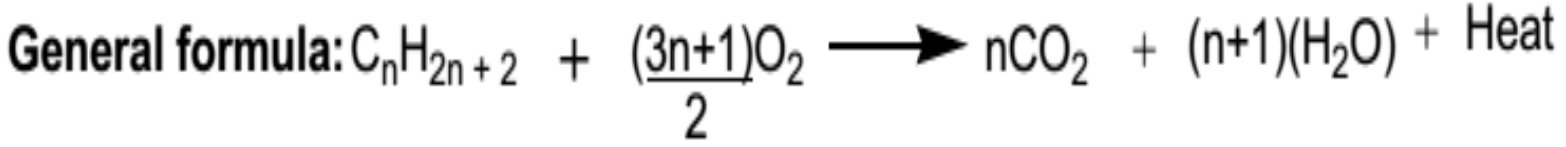
- An older name for alkanes is paraffin hydrocarbons.
- Paraffin is derived from the Latin words parum affinis (“with little affinity”) and testifies to the low level of reactivity of alkanes.

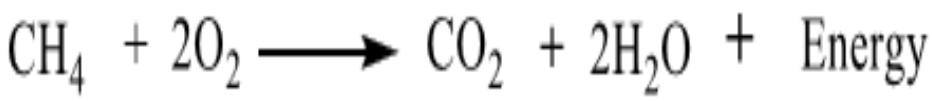
- Alkanes are comprised of sigma bonds (σ) which are unpolarized and therefore relatively unreactive.

Cont'd

A) Combustion: Like most other organic compounds, however, alkanes burn readily in air.

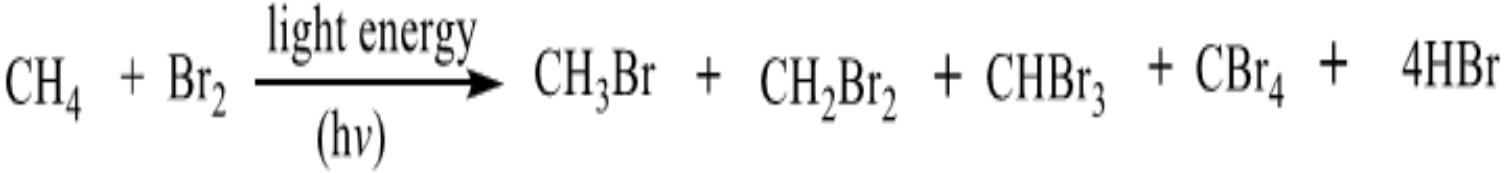
- This combination with oxygen is known as **combustion** and is **quite exothermic**.
- All hydrocarbons yield carbon dioxide and water as the products of their



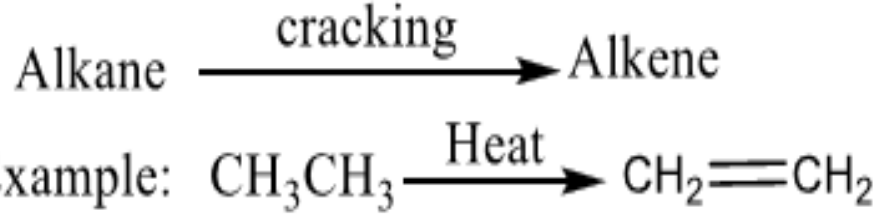


Cont'd

B) **Substitution Reaction or photochemical reaction or chain re**



C) **l**



on

2.2. Alkenes or Olefins (-C=C-)

- Alkenes are **unsaturated aliphatic hydrocarbons** that contain a carbon–carbon double bond.
- General formula is C_nH_{2n}

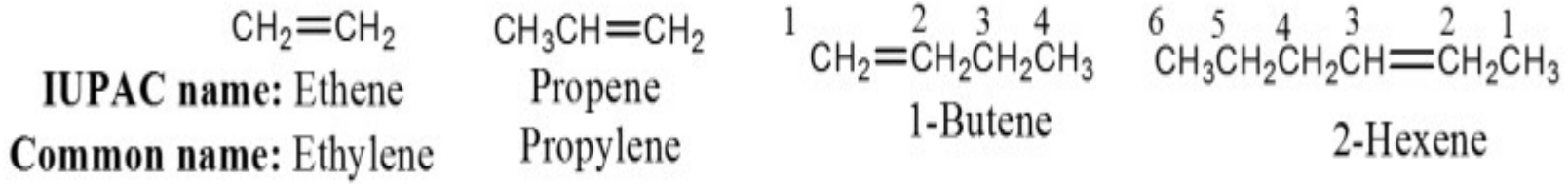
Alkene Nomenclature

- We give alkenes IUPAC names by replacing the -ane ending of the corresponding alkane with **–ene**.
- The two simplest alkenes are **ethene** and **propene**.

- Both are also well known by their common names ethylene and **propylene**.

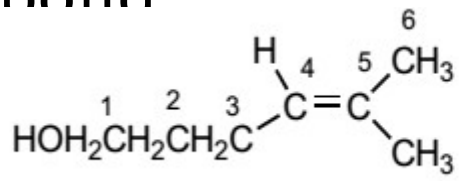
cont’d

- The position of the **double** or **triple** bond is indicated by the **number** of the lowest carbon atom in the alkene or alkyne.
- The longest continuous chain that includes the **double bond** forms the base name of the alkene



Cont'd

- Hydroxyl groups, however, outrank the double bond

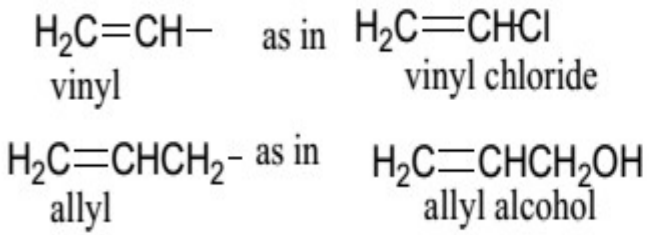


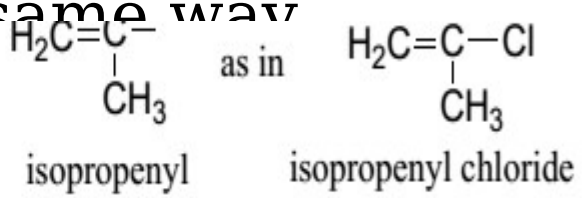
5-methylhex-4-en-1-ol Or 5-methyl-4-hexen-1-ol

Not 2-methyl-2-hexen-6-ol

- The common names of certain frequently encountered alkyl groups, such as isopropyl and tertbutyl, are acceptable in the IUPAC system.

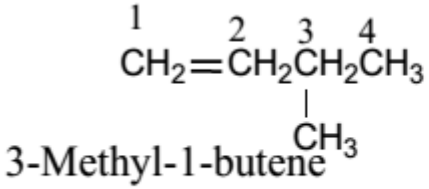
- Three alkenyl groups **vinyl, allyl**, and **isopropenyl** are treated the same way



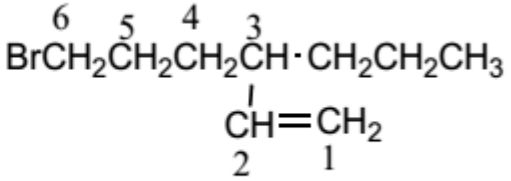


Cont’d

- Carbon–carbon double bonds take **precedence over** alkyl groups and halogens in determining the main carbon chain and the direction in which it is



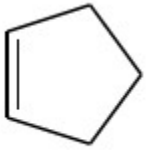
3-Methyl-1-butene



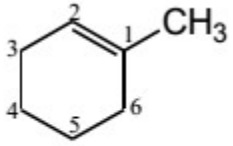
6-bromo-3-propyl-1-hexene

cont’d

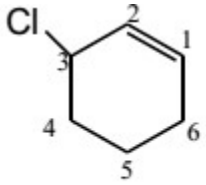
- Cycloalkenes and their derivatives are named by adapting cycloalkane terminology to the principles of alkene nomenclature



Cyclopentene



1-Methylcyclohexene



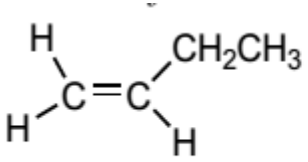
3-Chlorocyclohexene



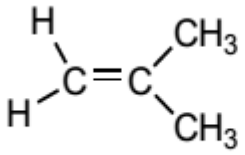
cyclobutene

Isomerism in Alkenes (chain or position or geometric Isomerism)

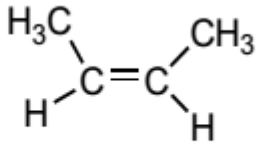
- there are four isomeric alkenes of molecular formula C_4H_8:



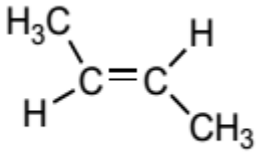
1-butene



2-methylpropene



cis-2-butene



trans-2-butene

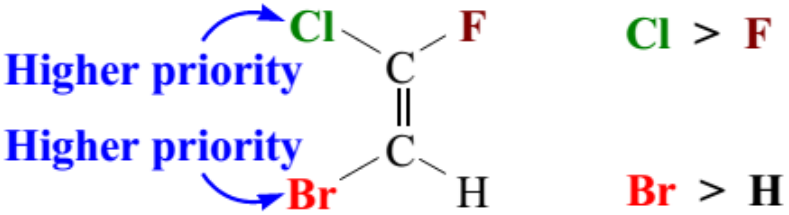
- Cis-2-Butene and trans-2-butene are Geometric stereoisomers
- the terms "**cis**" (on the same side) and "**trans**" (on opposite side) specify the configuration of the double bond

The (E)-(Z) System for Designating Alkene Diastereomers

- Cis- and trans- designations the stereochemistry of alkene diasteroemers are unambiguous only when applied to disubstituted alkenes.

- The (E)-(Z) system:
  - (Z)-alkene: If the two groups of higher priority are on the same side of the double bond (German: zusammen, meaning together).
  - (E)-alkene: If the two groups of higher priority are on opposite side of the double bond (German: entgegen, meaning opposite).

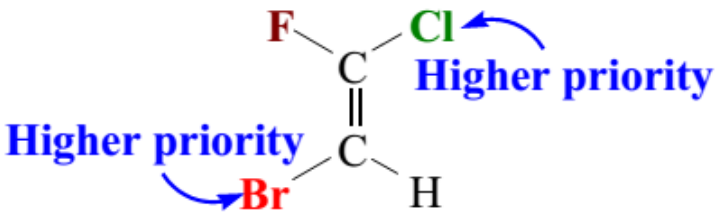
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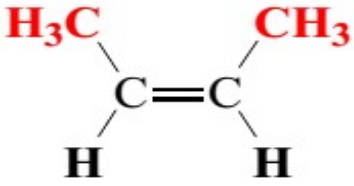
Cl > F

Br > H

(*Z*)-2-Bromo-1-chloro-1-fluroethene

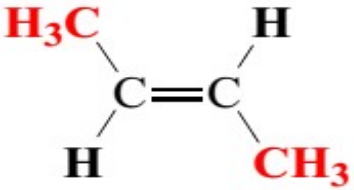


(*E*)-2-Bromo-1-chloro-1-fluroethene

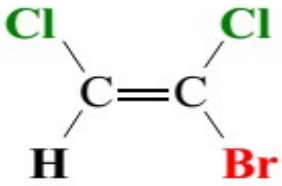


(*Z*)-2-Butene
(*cis*-2-butene)

CH_3 > H

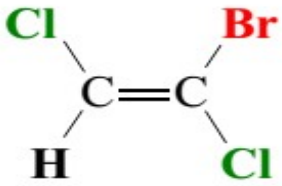


(*E*)-2-Butene
(*trans*-2-butene)



(*E*)-1-Bromo-1,2-dichloroethene

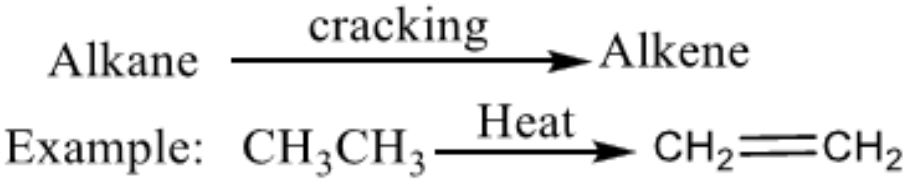
Cl > H
Br > Cl



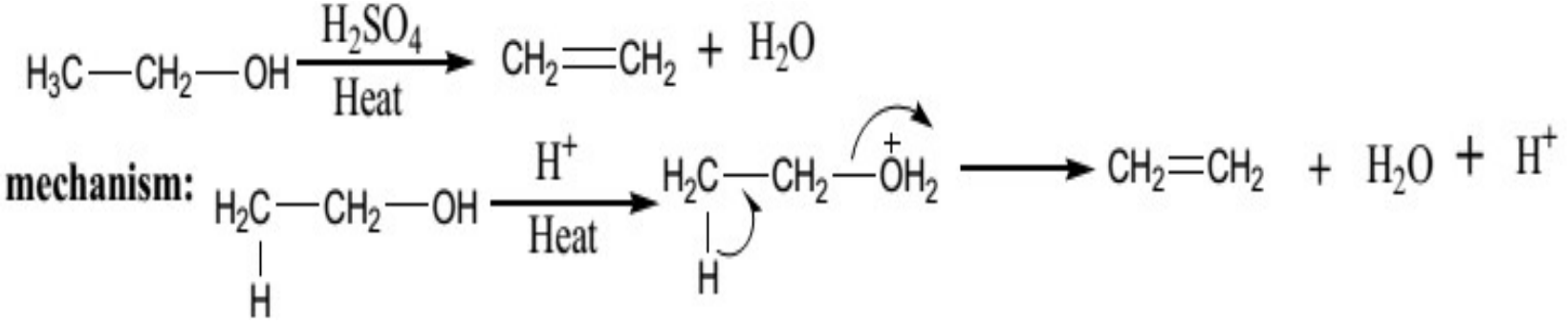
(*Z*)-1-Bromo-1,2-dichloroethene

Preparation of Alkenes

1. Industrial Source: Petroleum

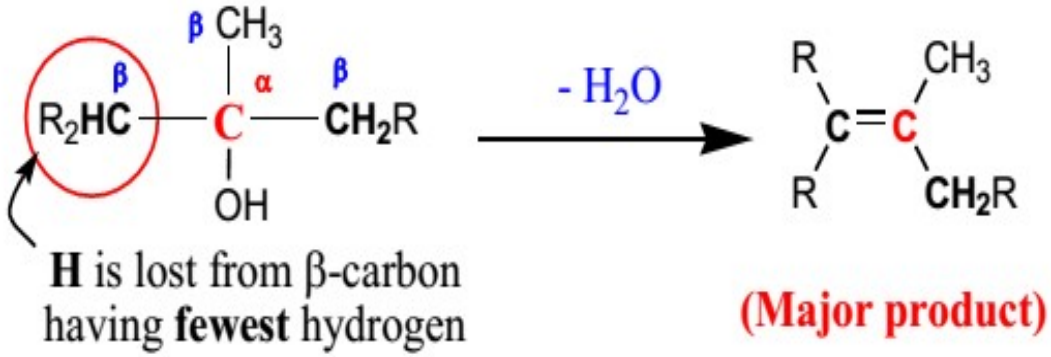


2. Dehydration of Alcohols



Cont'd

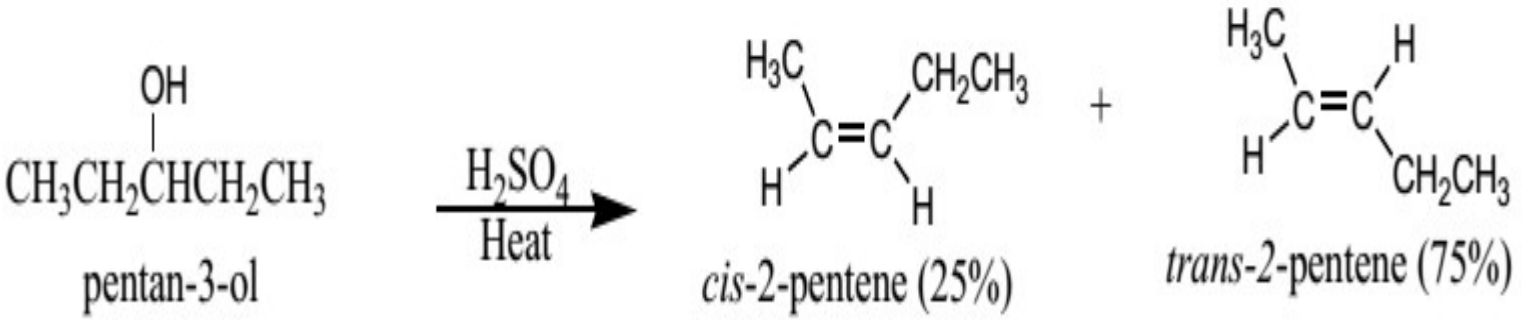
- **Zaitsev's rule stated** that the alkene formed in greatest amount is the one that corresponds to removal of the hydrogen from the β-carbon having the **fewest hydrogens**.
- In other words β-elimination reactions of alcohols yield th e **major** p



cont’d

- Alcohol dehydrations are stereoselective.

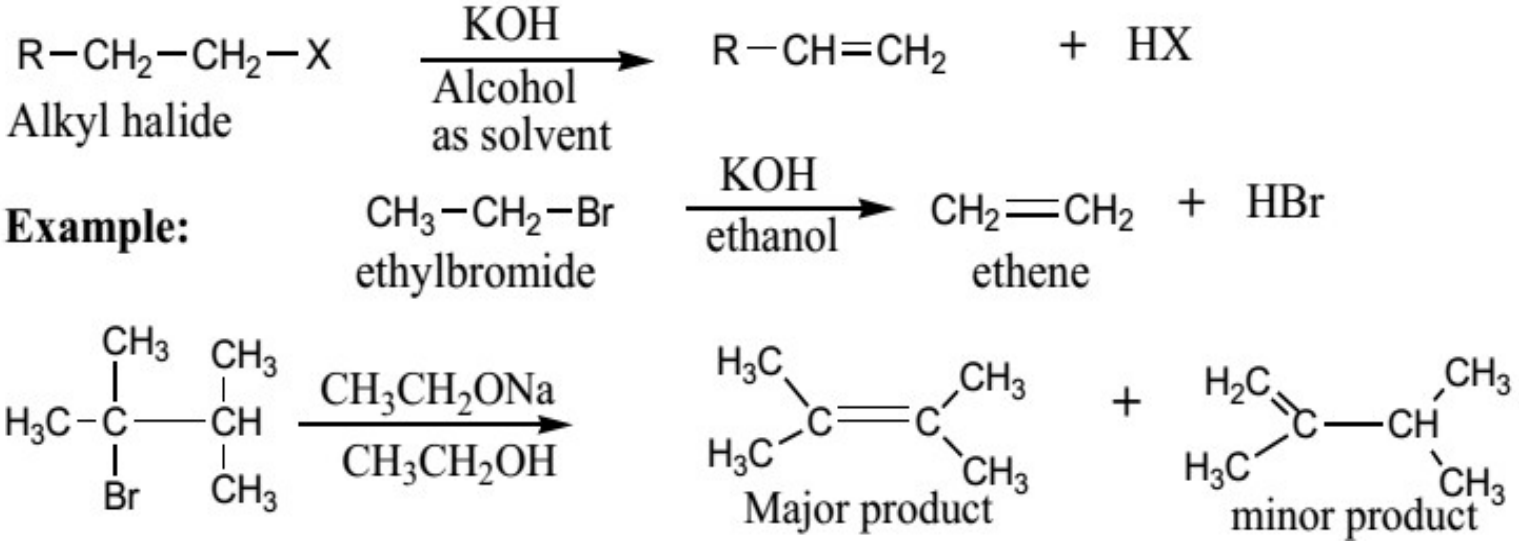
- A stereoselective reaction is one in which a single starting material can yield two or more stereoisomeric products, but gives one of them



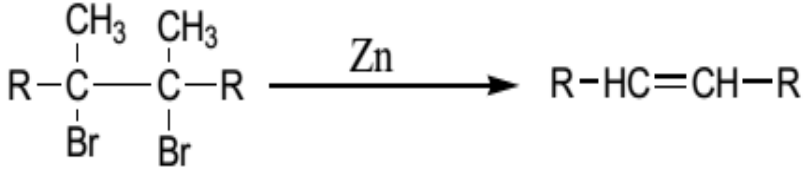
3. Dehydrohalogenation of Alkyl halides

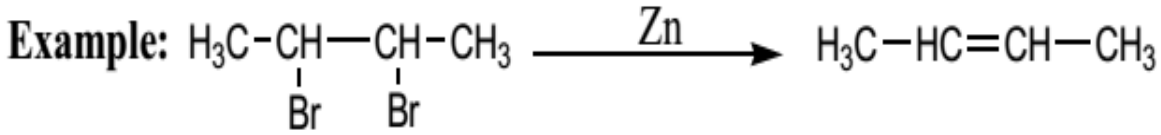
- Dehydrohalogenation is the loss of **hydrogen** and a **halogen** from an alkyl halide.

- The ease of dehydrogenation of alkyl halide is 3^o alkyl halide $>2^o$ alkyl halide $>1^o$ alkyl



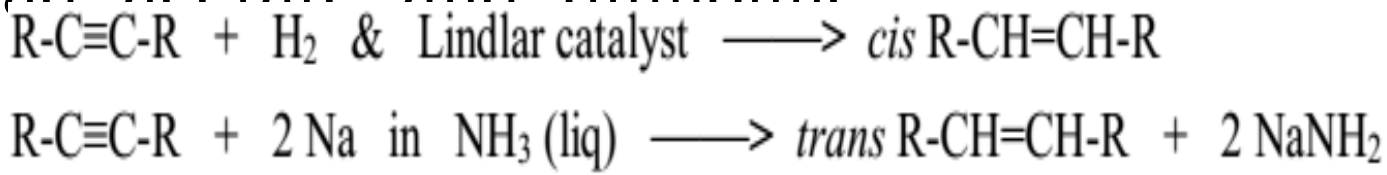
4. Dehallogenation of Vicinal Dihalides





5. Reduction of Alkynes

- Lindlar's catalyst, prepared by deactivating (or poisoning) a palladium catalyst on calcium carbonate combination by treating it with lead acetate and quinoline



Properties of Alkenes

A. Physical properties:

- The first three members are gases at ordinary temperature, next **14 are liquids** and the **higher ones** are solids.
- Except ethylene, all members are colorless and odorless.
- Ethylene is pleasant smelling gas.
- Alkenes are only slightly soluble in water but soluble in non-polar solvents

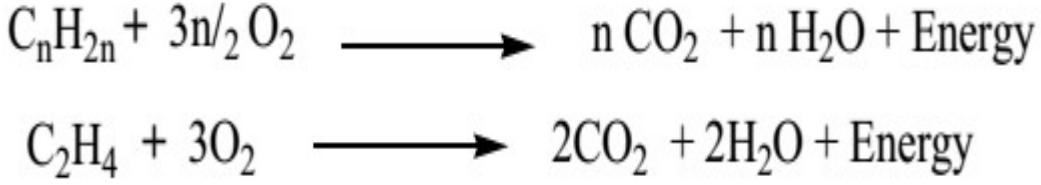
Cont’d

- Generally, their boiling points, melting points and specific gravities rise with increase of molecular weights.

- Further, like alkanes, the branched chain alkenes have lower boiling points than the corresponding n-alkenes.

B. Reactions of Alkenes

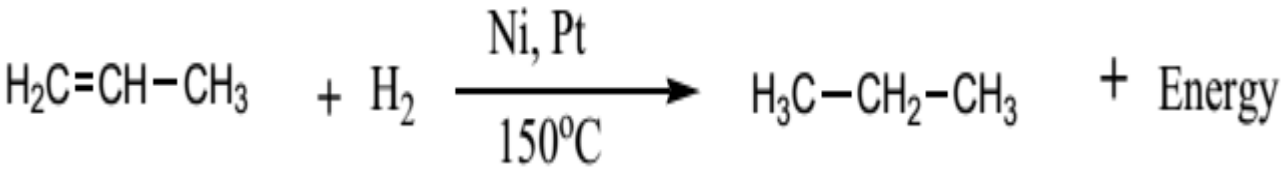
1. Combustion Reaction



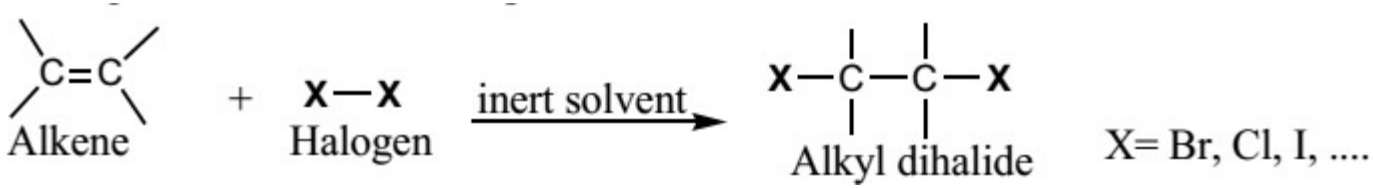
2. Addition Reaction

- The characteristic reaction of alkenes is addition to the double bond.

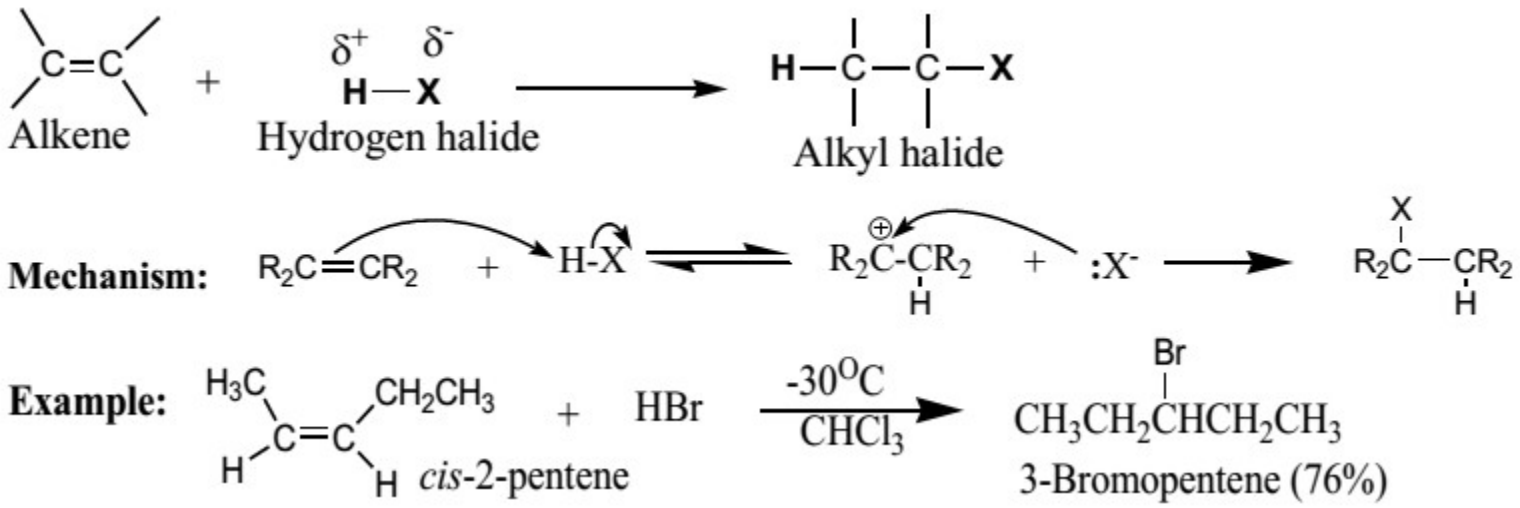
A. Hydrogenation



B. Addition of Halogen



C. Electrophilic Addition of Hydrogen Halides



Cont’d

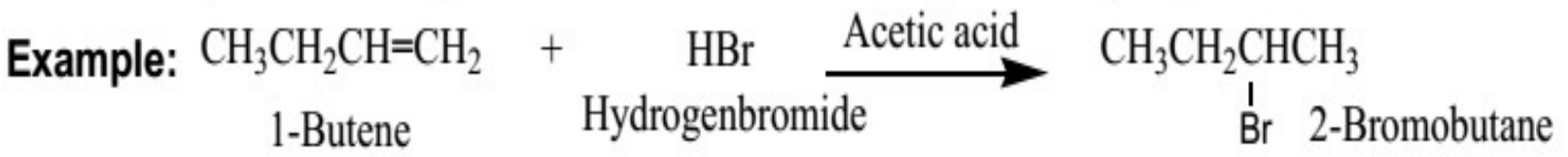
- The reactivity of the hydrogen halides reflects their ability to donate a proton.
- Hydrogen iodide is the strongest acid of the hydrogen halides and reacts with alkenes at the fastest rate.

$$HF \ll HCl < HBr < HI$$

Slowest rate of addition — Fastest rate of addition

cont'd

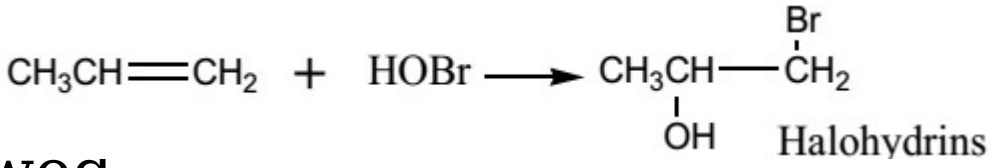
- **Markovnikov's rule:** states that when an unsymmetrically substituted alkene reacts with a hydrogen halide, the hydrogen adds to the carbon that has the greater number of hydrogen substituents, and the halogen adds to the carbon having fewer hydrogen substituents.



cont'd

- **Anti-Markovnikov's rule:** Anti-Markovnikov addition occurred when peroxides, that is, organic compounds of the type ROOR, were present in the reaction mixture.

D. Addition of Hypohalous acid:

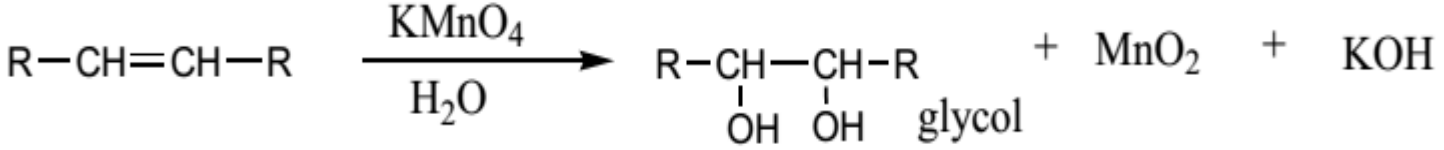
- In hypohalous acid (HOX) –OH is more negative part.
- They add to alkene to give halohydrin.
- In case of 

kov's rule is followed.

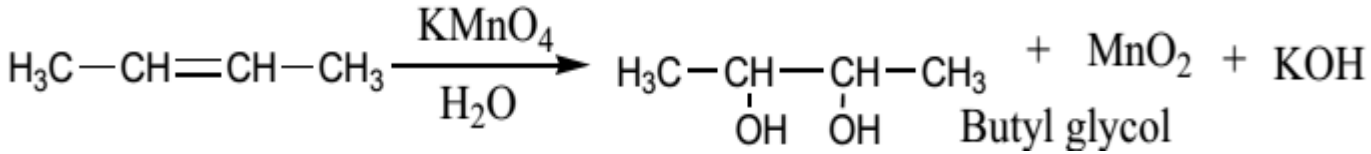
3. Oxidation

- Alkane undergo oxidation reaction readily to form different compounds under different conditions.

A. Oxidation with dilute Cold $KMnO_4$



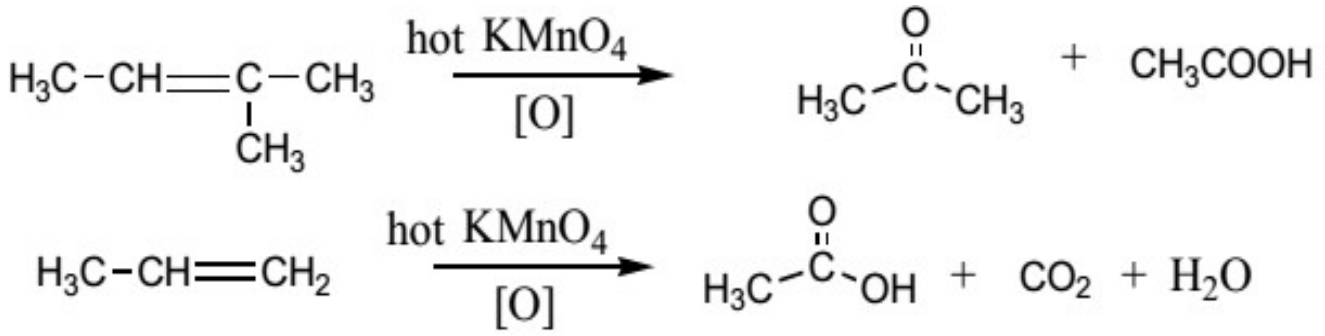
Example:



Cont’d

B. Oxidation with Hot $KMnO_4$: Alkene on treatment with hot potassium permanganate solution split at the double bond to form ketone and /or acids.

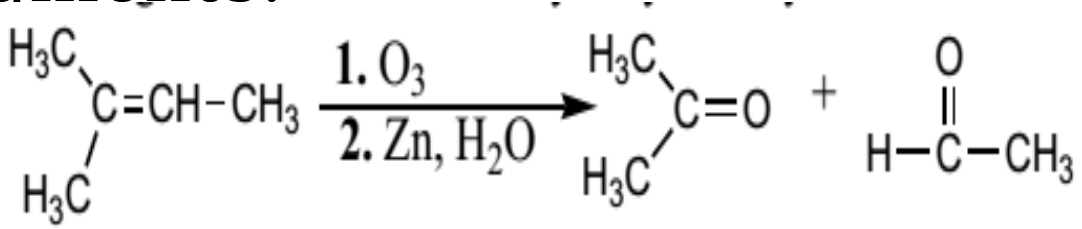
Example:



cont’d

C) Oxidation with ozone: Ozone adds to an alkene molecule to form an ozonide.

- Ozonide on warming with zinc and water hydrolyzed to yield smaller carbonyl fragments.

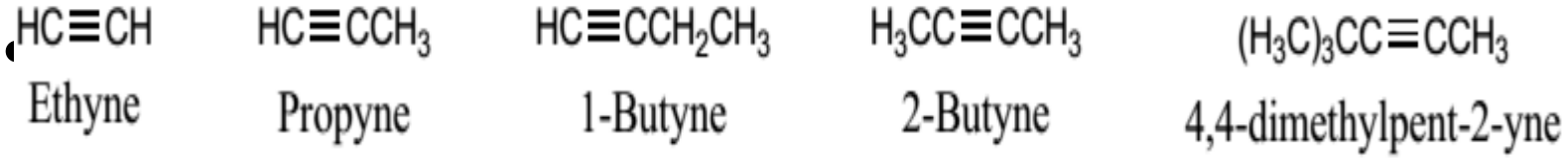


2.3. Alkynes

- Unsaturated aliphatic hydrocarbons that contain a carbon–carbon triple bond are called **alkynes**.
- Noncyclic alkynes have the molecular formula C_nH_{2n-2}.

Nomenclature of Alkynes

IUPAC = Alkane-ane + yne = Alkyne



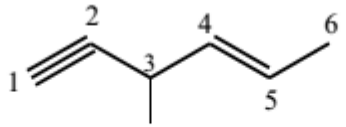
Cont’d

- **Enynes**: containing both **double** and **triple** bond.
- With both -enes and -ynes, suffix is -en-yne and numbering is from the end closer to a multiple bond.

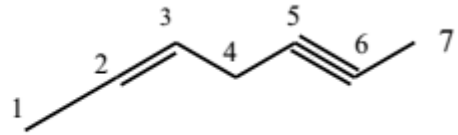
- When there is equal chance in numbering,



1-Hepten-6-yne



3-methyl-4-hexene-1-yne

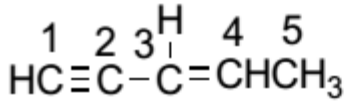


hept-2-en-5-yne or 2,5-heptenyne

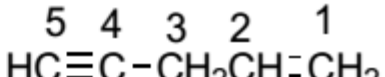
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- In the case where each would have the same position number, the double bond takes the low

Example:



Pent-3-en-1-yne



Pent-1-en-4-yne

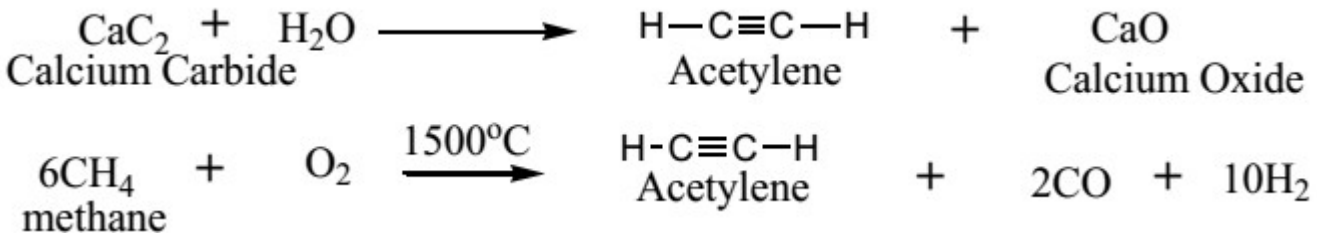
- Th

Common name	IUPAC name	Structure
Acetylene	Ethyne	HC≡CH
Methyl acetylene	Propyne	$CH_3C{\equiv}CH$
Dimethyl acetylene	2-butyne	$H_3CC{\equiv}CCH_3$

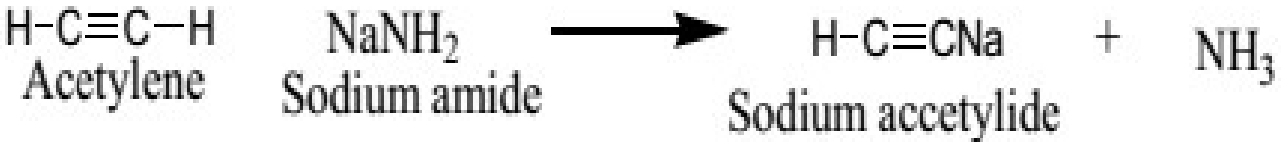
or triple bo

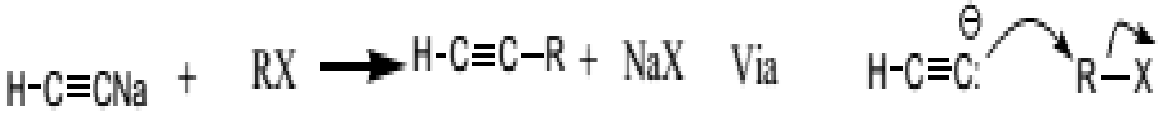
Preparation of Alkynes

- Industrial Source of Acetylene (Reaction of Calcium Carbide with H_2O)

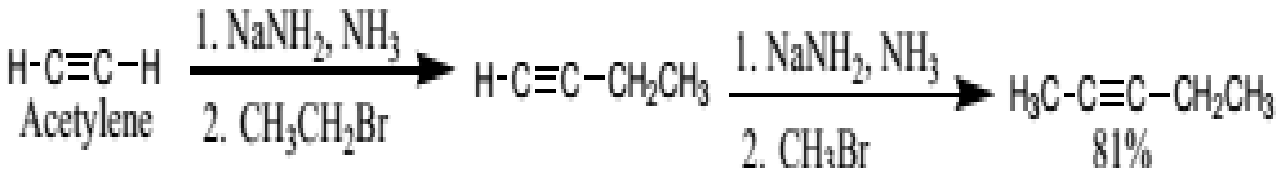


2. Alkylation of Acetylene and Terminal Alkynes



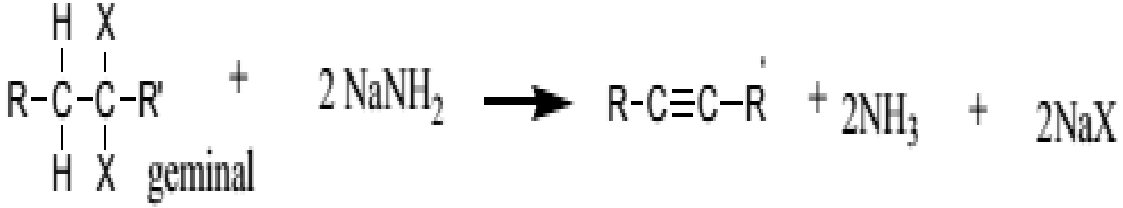




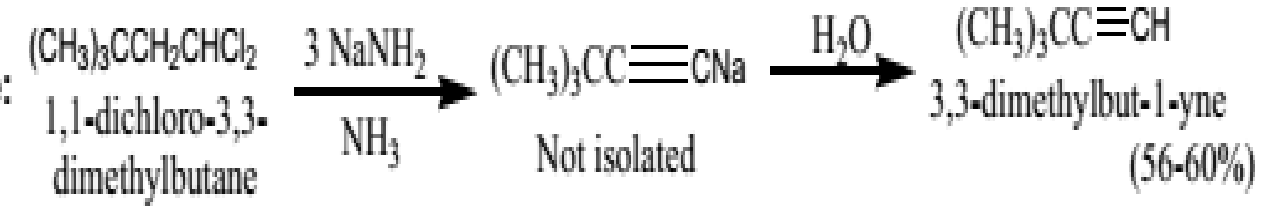


3. Dehydrohalogenation of Dihaloalkanes

- Double dehydrohalogenation of a geminal dihalide

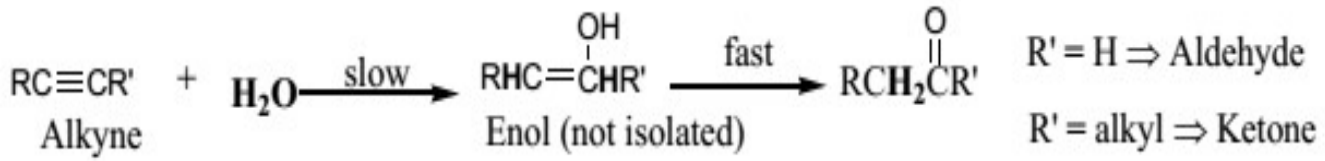


- Adding water or acid after the reaction is complete converts the sodium salt to the corresponding alkyne



Reactions of Alkynes

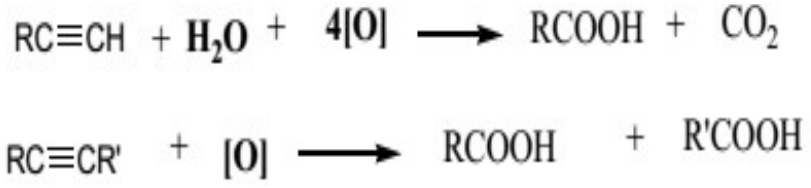
1. Hydrogenation of Alkynes
2. Metal–Ammonia Reduction of Alkynes
3. Addition by Electrophilic Reagents-halogenation
4. Addition of Hydrogen Halides to Alkyne
   - Follows Markovnikov's rule
5. Hydration of Alkynes



- The process by which enols are converted to aldehydes or ketones is called ***keto–enol* isomerism** (or *keto–enol tautomerism*).

6. Oxidations

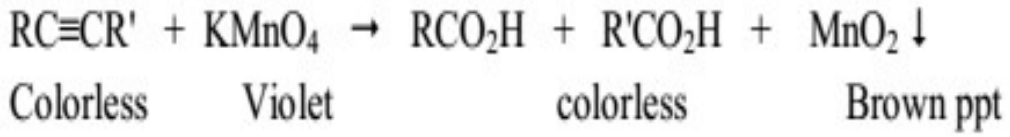
- Reactions of alkynes with oxidizing agents such as potassium permanganate and ozone usually result in cleavage of the triple-bond to give carboxylic acid products



$$RC{\equiv}CH + H_2O + 4[O] \longrightarrow RCOOH + CO_2$$

$$RC{\equiv}CR' + [O] \longrightarrow RCOOH + R'COOH$$

- Oxidat anate



$$RC{\equiv}CR' + KMnO_4 \rightarrow RCO_2H + R'CO_2H + MnO_2\downarrow$$

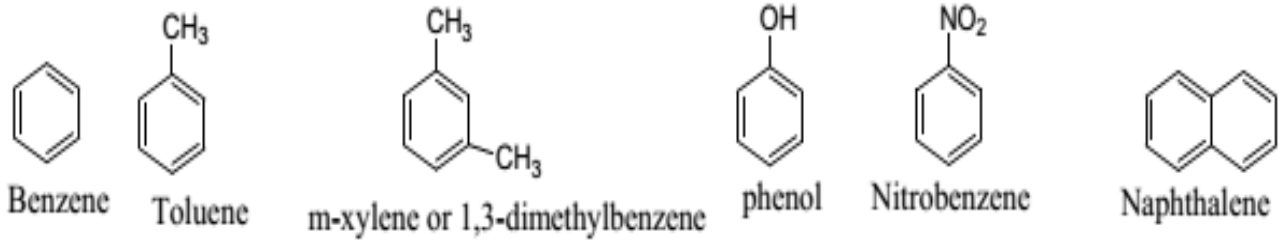
Colorless Violet colorless Brown ppt

2.4. Aromatic Compounds

- Aromatic compounds are substances that contain a benzene ring or similar 'aromatic' system



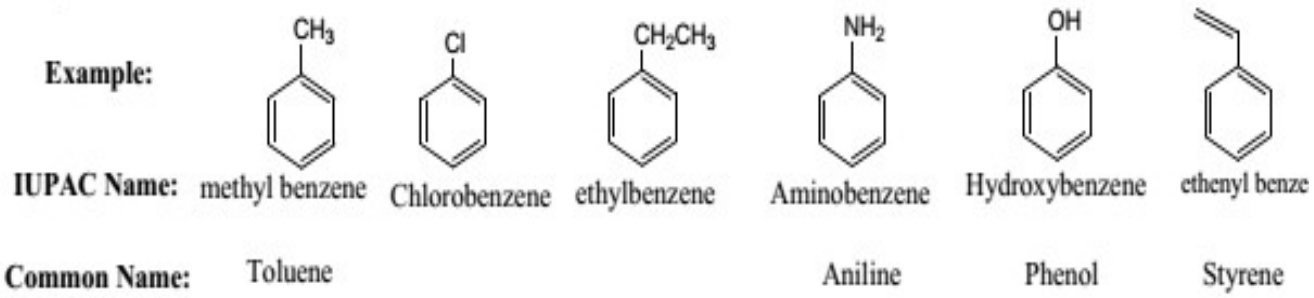
Be



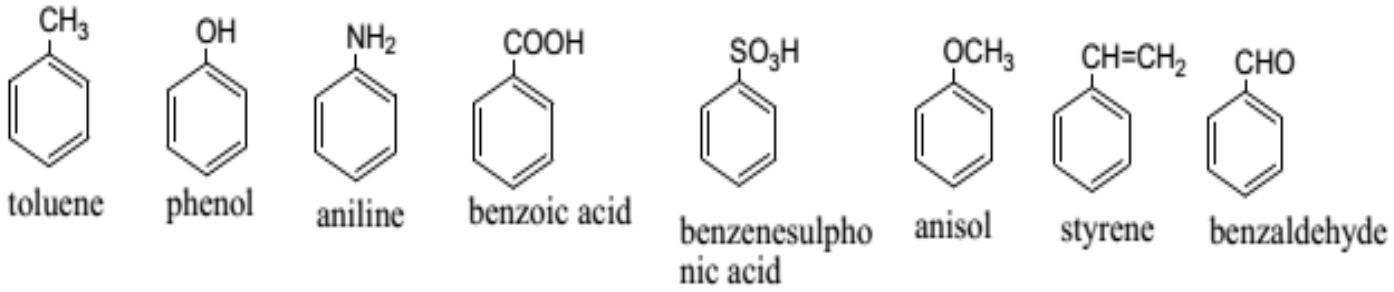
Nomenclature of benzene derivatives

A. Monosubstituted benzenes:

- When a single hydrogen of the benzene ring is replaced, the compound can be named as "substituent benzene" or as derivative of benzene.

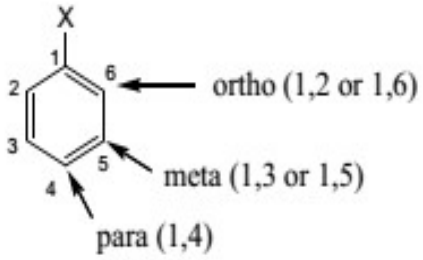


- **Common names** of special monosubstituted]

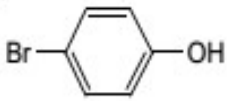


B. Disubstituted benzene

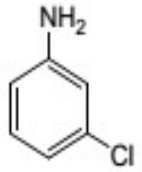
- There are two ways that disubstituted benzene derivatives can be named: Ortho-Meta-Para Designation and Numbering approach.



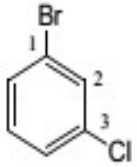
Example:



para-bromophenol

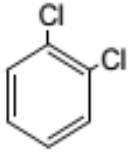


meta-chlorobenzenamine

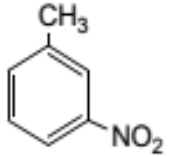


m-bromochlorobenzene
or 1-bromo-3-chlorobenzene

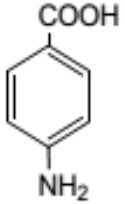
- For groups that are part of special monosubstituted benzenes; the special group is at positision **1**



ortho-dichorobenzene
or 1.2-dichlorobenzene



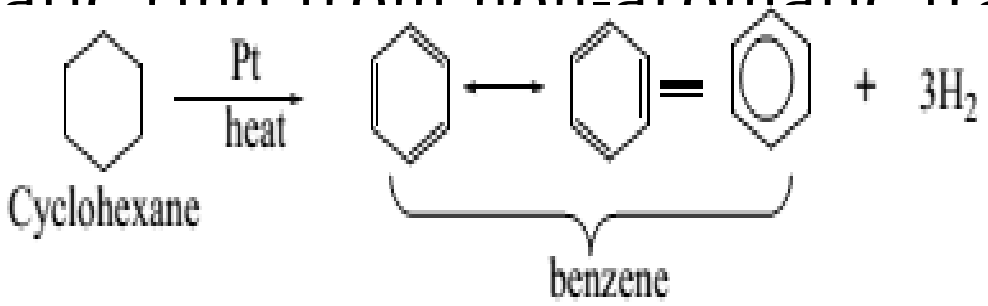
meta-nitrotoluene
or 3-nitrotoluene



para-aminobenzoic acid
or 4-aminobenzoic acid

Preparation of aromatic compounds

- Aromatic compounds are usually synthesized by modifying structures that already have an aromatic ring rather than by generating the aromatic ring from non-aromatic fragment.



Properties of aromatic compounds

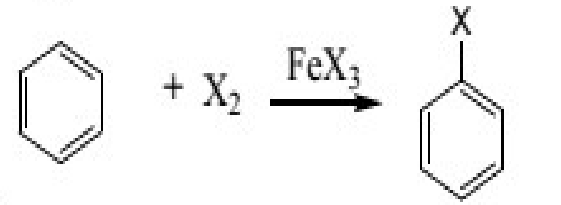
- The physical properties of benzene and other aromatic hydrocarbons are similar to those of **alkanes and alkenes**.
- They are nonpolar and thus insoluble in water.
- Aromatic rings are relatively stable chemically. Because of this, benzene often reacts in such a way that the aromatic ring remains intact

- Thus, benzene does not undergo the **addition reactions** that are characteristic of **alkenes** and **alkynes**.

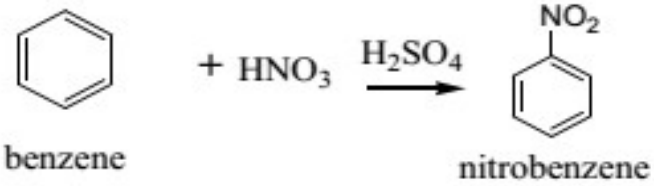
- The predominant type of reaction for aromatic molecules is **substitution**, in which some other group replaces one of the ring hydrogen.

Electrophilic Aromatic Substitution Reaction

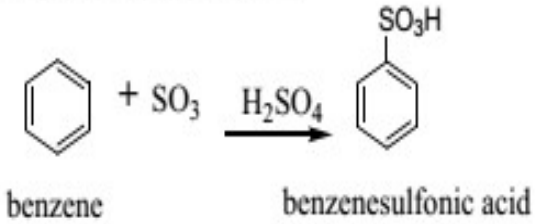
Halogenations of Benzene



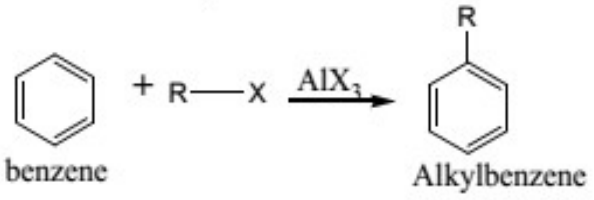
Nitration of Benzene



Sulfonations of Benzene



Friedel -Craft Alkylation of Benzene



Friedel -Craft Acylation of Benzene

