

CHM 102 Summary note (Organic chemistry)

EliteMedia
08164824018

Elaboration Revision

CHS 102

- Van Jacobs Berzelius propounded vital force theory in the year 1828
- Vital force theory states that all organic Compounds are produced from living organism due to the influence of a vital force
- Friedrich Wöhler produced the first organic Compound in the laboratory. He heated Ammonium Cyanate $\text{CONH}_4\text{CNO}_3$ to produce Urea $\text{CO(NH}_2)_2$



Isomerism \rightarrow Structural theory - bonding
Chemical reaction.

Organic Chemistry terms

- Homologues Series - are group of Compounds in which the various members have similar structural features and similar chemical properties which shares the same general formulae

- Bond length - is defined as the distance between the centre of two covalent bond atoms.
 - Covalent bond - this is a bond formed by the sharing of electrons through the overlap of atomic orbitals or molecular orbital.
 - Bond angle : is the angle formed by the intersection of two covalent bonds at the atom common to both.
 - Bond Cleavage - This is the splitting of chemical bonds.
 - Homolytic Cleavage ; is the breaking of a bond to form two neutral species.
- $$\overset{\circ}{X}-\overset{\circ}{Y} \longrightarrow X^{\circ} + Y^{\circ}$$
- Heterolytic Cleavage ; This is the breaking of a bond to form a pair of oppositely charged atoms. They produce charge species (ions)
- $$\overset{\circ}{X}-\overset{\circ}{Y} \longrightarrow X^{+} + Y^{-}$$
- Function group - is an atom or group of atoms in a molecule that gives the molecule its characteristic chemical properties.

Functional group

Class	Formula
Alkyl halides	R_X
Aryl halides	ArX
Alcohols	ROH
Phenols	$ArOH$
Ethers	COC
Aldehydes (Alkanals)	$RCCHO$
Ketones (Alkanones)	$R-C(=O)R$
Carboxylic acid	$RCOOH$
Esters (Alkanates)	RCO_2R
Amides	$RCONHR$
Amines	RNH_2
Nitriles	$RC\equiv N$
Cyanides	

Molecule	Hybridization	Bond length	Bond angle	Shape	General formula	Sigma bond	Pi bond
Methane	SP^3	1.09 nm	109.5°	Tetrahedral	C_4H_{10}	4	0
Ethane	SP^2	1.47	120°	tri. planar	C_2H_6	2	2
Alkyne	SP	1.91	180°	linear	C_2H_2	2	2
					C_2H_4	2	2
					C_3H_6	3	3
					C_2H_2	2	2

Nomenclature

Simple root

Chain length	word root	Chain length	word root
C ₁	Meth-	C ₁₁	Undee-
C ₂	Eth-	C ₁₂	Dodec-
C ₃	Prop-	C ₁₃	Tridec-
C ₄	But-	C ₁₄	Tetradec-
C ₅	Pent-	C ₁₅	Pentadec-
C ₆	Hex-	C ₁₆	Hexadec-
C ₇	Hept-	C ₁₇	Heptadec-
C ₈	Oct-	C ₁₈	Octadec-
C ₉	Non-	C ₁₉	Nona dee-
C ₁₀	Dec-	C ₂₀	Eicos-

Prefixe

- n (Normal) is used for those alkanes in which all the carbon atoms form a continuous chain without branching.
- + Isop - one methyl group is attached to next to end of the continuous chain.
- Neo - two methyl groups is attached to the second last carbon atom of the continuous chain.

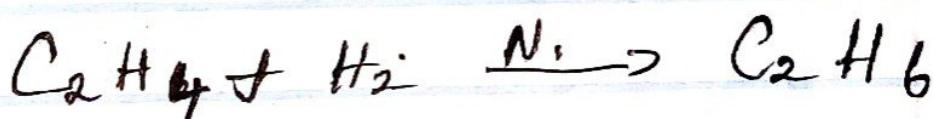
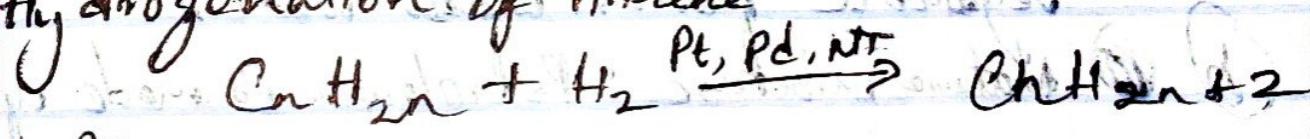
Rules in naming Compounds

- ① Find the longest chain
- ② Position of the substituent
- ③ Name Compound starting from the substituent and end with the parent name.
 - * If substituents are the same you start naming according to their position.
 - * If substituents are different you start naming them alphabetically.

Preparations of Organic Compounds

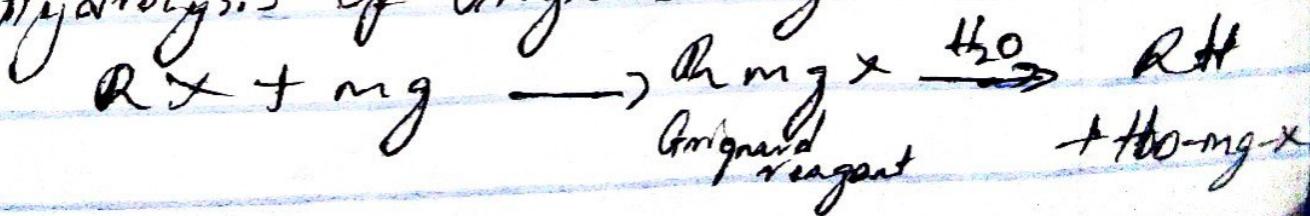
Alkanes

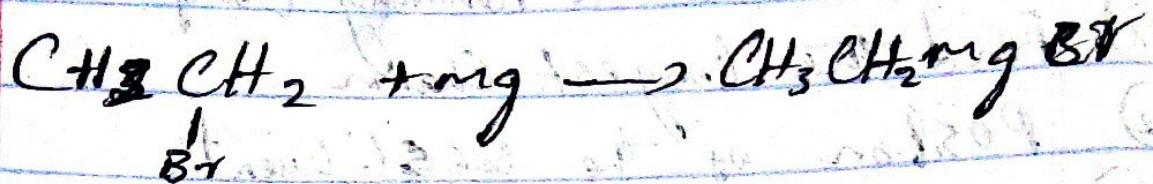
- ① Hydrogenation of Alkene



- ② Reduction of Alkyne halides

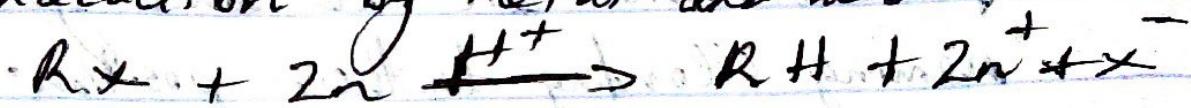
- ③ Hydrolysis of Grignard reagent





②

Reduction by metal and acid



③

Coupling of alkyl halides with organo-metallic Compounds



Industrial preparation

④

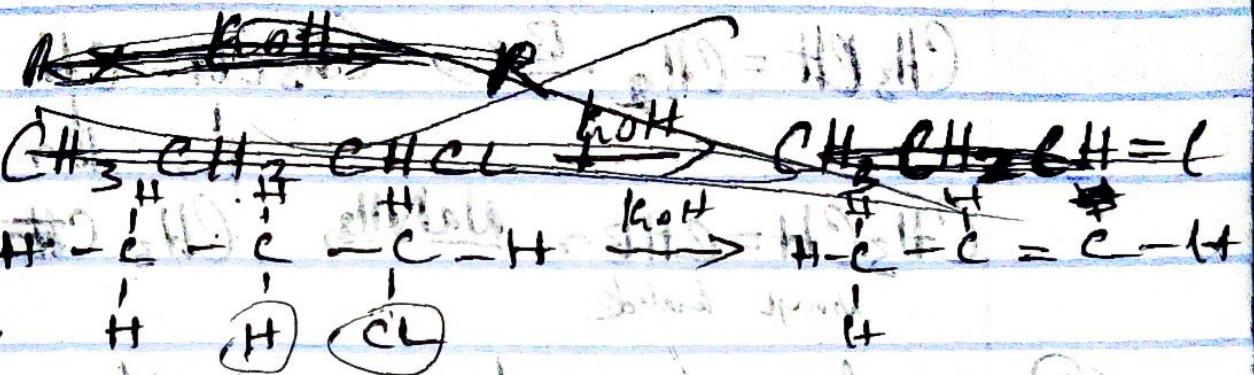
Anaerobic bacterial decomposition from vegetable matter under water

⑤

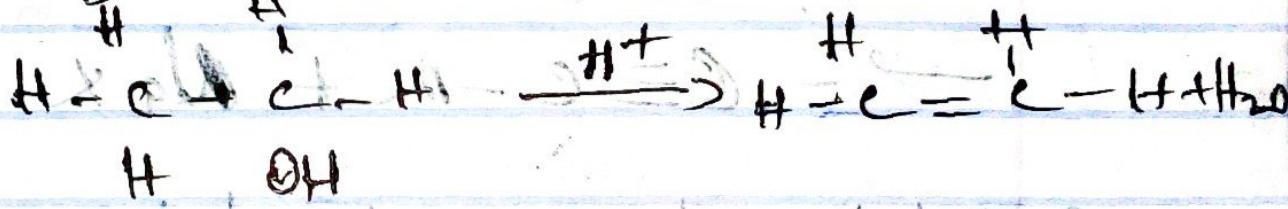
Nature mixture : Petroleum is made up of alkanes

Preparation of Alkenes

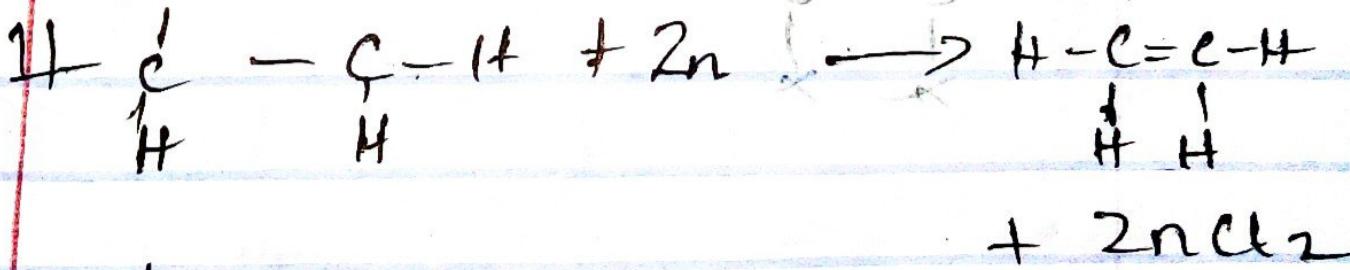
① Dehydrohalogenation of Alkyl halides



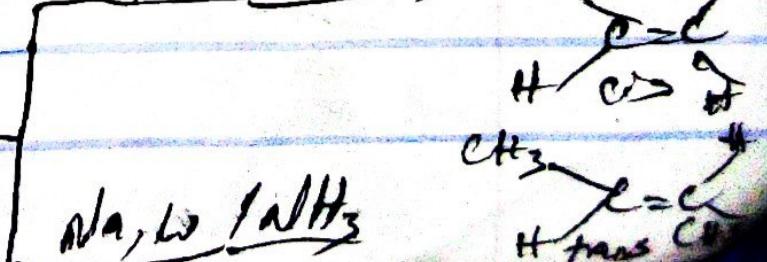
② Dehydration of Alcohols



③ Dehalogenation of Vilsmeier dihalides

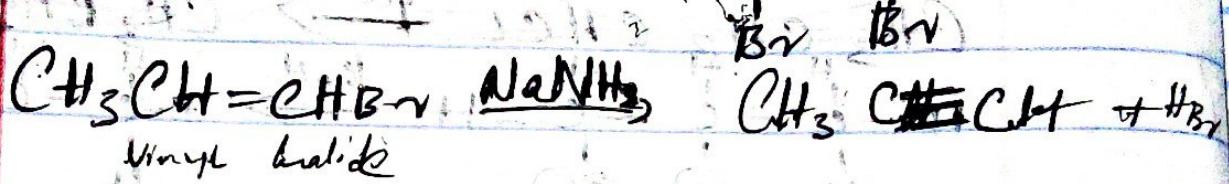


④ Reduction of Alkynes

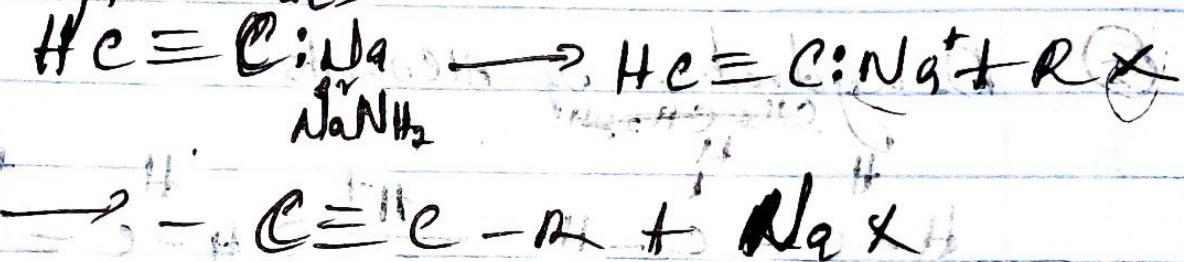


Preparation of Alkynes

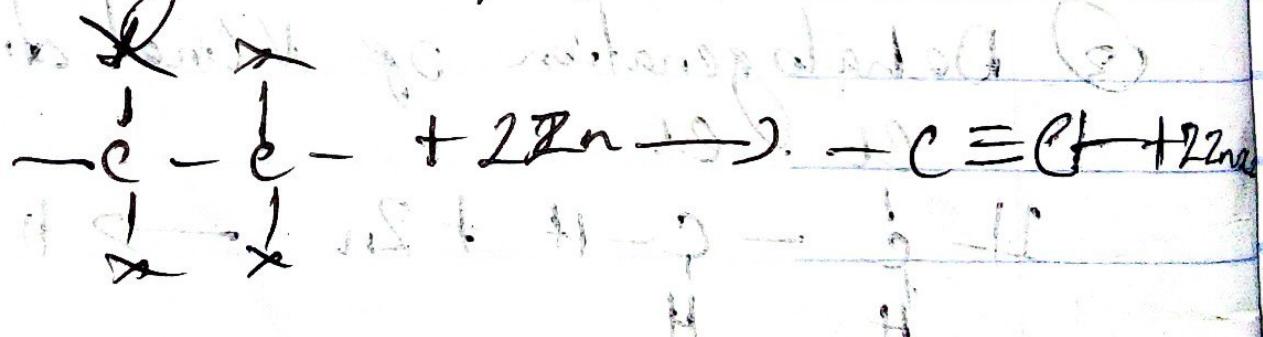
① Dehydrohalogenation of Alkyl halides



② Reaction of Sodium acetylides with primary alkyl halides



③ Dehalogenation of tetrahalides

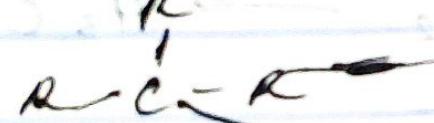


Reactions of Alkane

Types of Carbons

- ① Quaternary Carbon → Attached to 4 other carbons
- ② Tertiary Carbon → Attached to 3 other carbons
- ③ Secondary Carbons → + 1 X 2 1 - 2 -
- ④ Primary Carbons → + 1 X 1 1 - 1 -

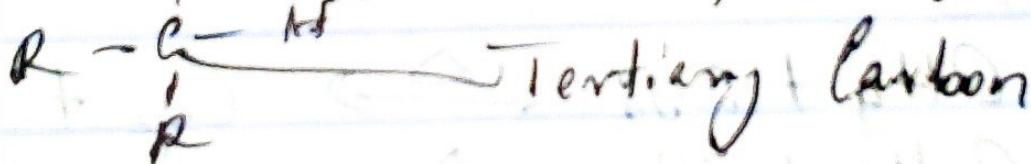
N.B. Any hydrogen added to a primary carbon is also called a primary hydrogen.



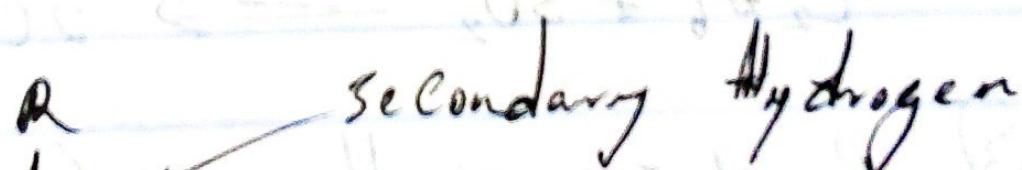
Quaternary Carbon



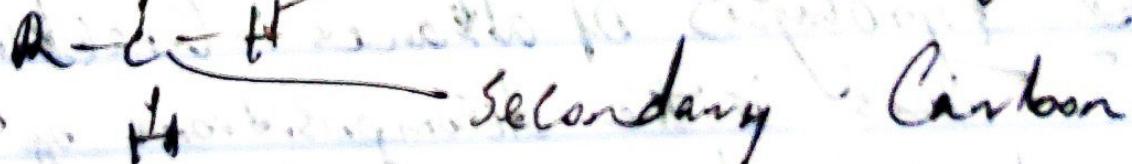
Tertiary Hydrogen



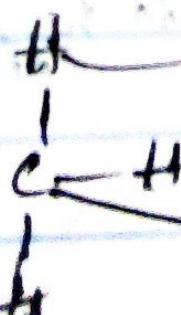
Tertiary Carbon



Secondary Hydrogen



Secondary Carbon



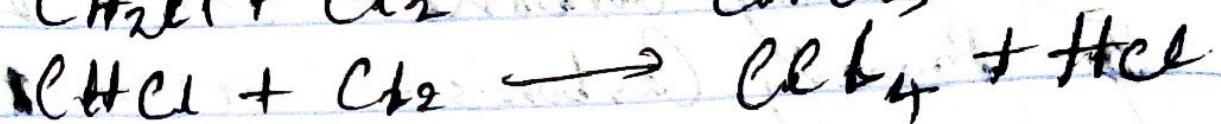
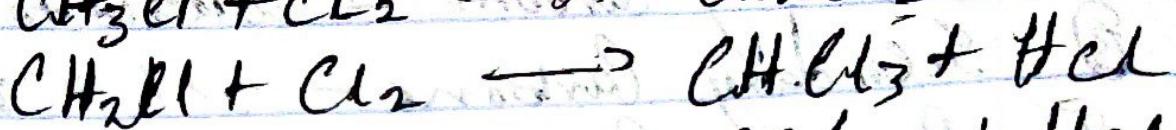
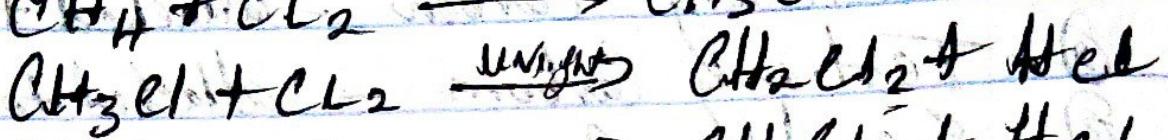
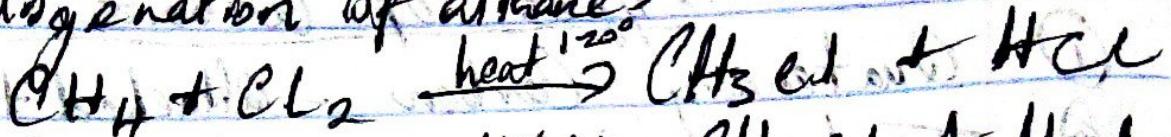
Primary Hydrogen



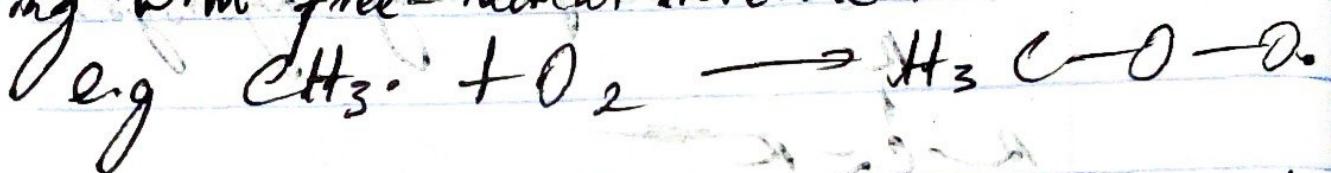
Primary Carbon

Reactions of alkanes

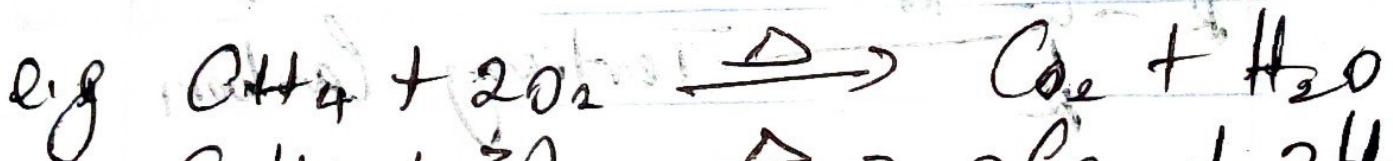
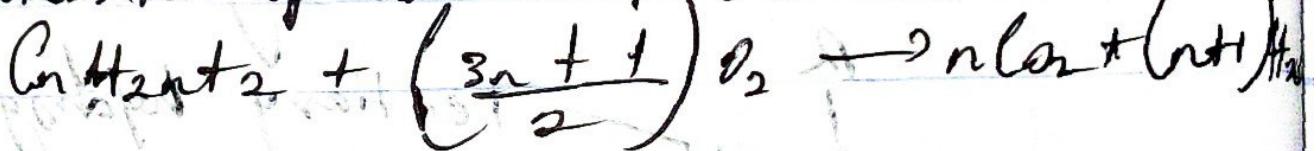
① Halogenation of alkanes



NB Inhibitors stop chain propagation by reacting with free-radical intermediates

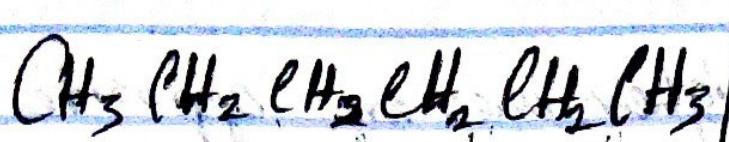


② Combustion of alkanes



③ Pyrolysis of alkanes & Cracking

This is the decomposition of a compound by the action of heat, it happens in the absence of air.



$\text{C}_2\text{H}_{10} + \text{C}_2\text{H}_4$
butane ethene

$\text{C}_3\text{H}_6 + \text{C}_2\text{H}_4 + \text{C}_2\text{H}_2$
Propene isobutane Ethene

$\text{C}_6\text{H}_{12} + \text{H}_2$
hexane

Geometric Isomerism (rigidity)

In this isomerism, the connectivity is the same and the arrangement in space are different

Types of Geometric Isomerism

(a)

The cis

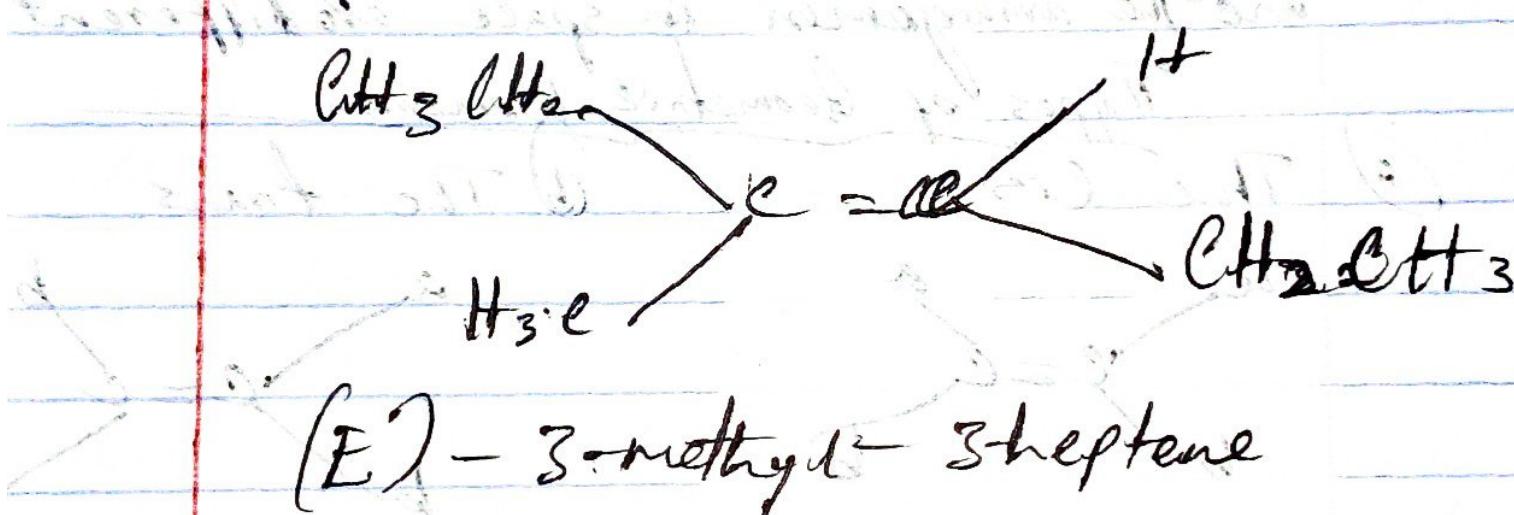
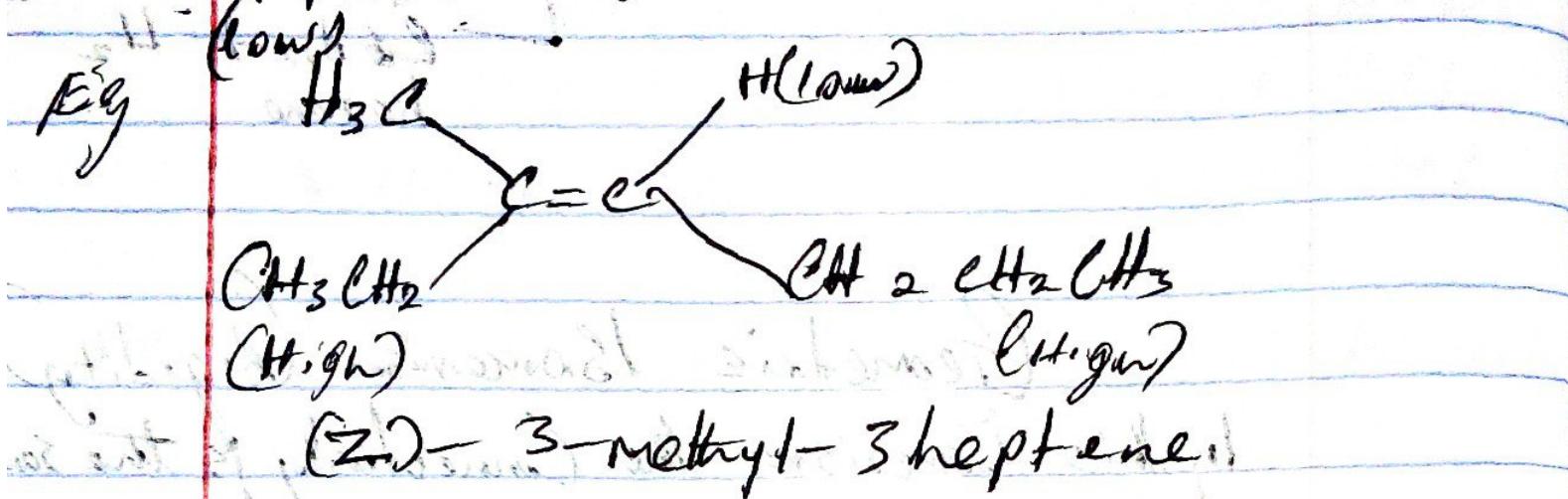
(b) The trans



When there are no similar groups between the isomers we assign priority preliminary E and Z notation using the Cahn Ingold - Prelog priority

* If the higher one are on the same side name it (Z).

Like the higher ones are opposite name to E
If you are using Z and E put them in brackets

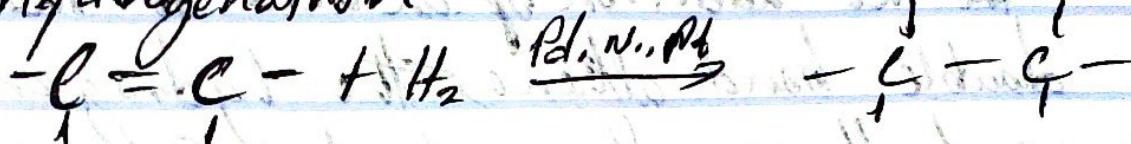


Reactions of alkenes

The first type of reaction of alkene is the breaking of pi bond. This is done when we have an electrophile around it. This reaction is known Addition Reaction.

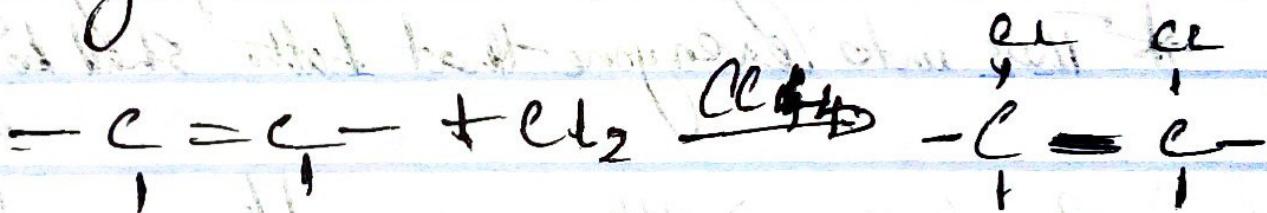
(a)

Hydrogenation

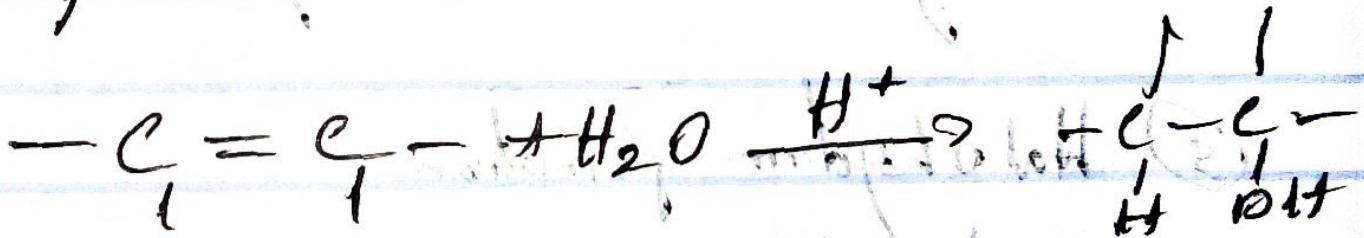


(b)

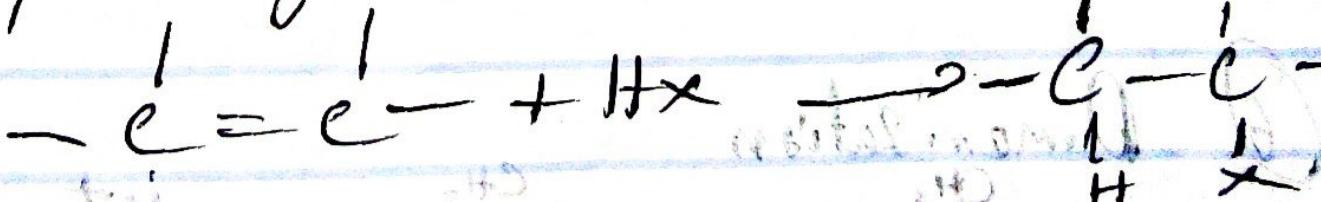
Halogenation



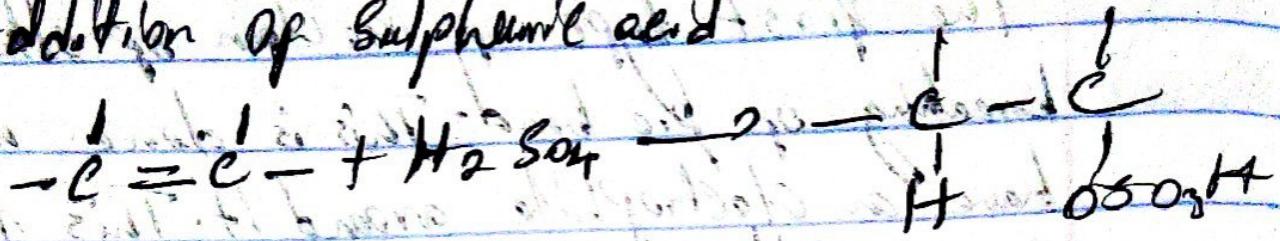
(c) Hydration



(d) Hydrohalogenation



② Addition of Sulphuric acid



Maklowon Rule

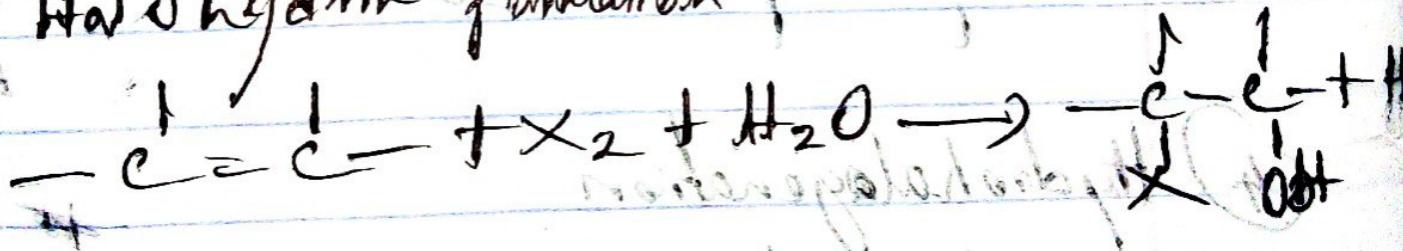
In the addition of an acid to the $\text{C}=\text{C}$ double bond alkene, the hydrogen of the acid attaches itself to the carbon that already holds the greater number of hydrogens.

* This note everyone that Hato shall be given

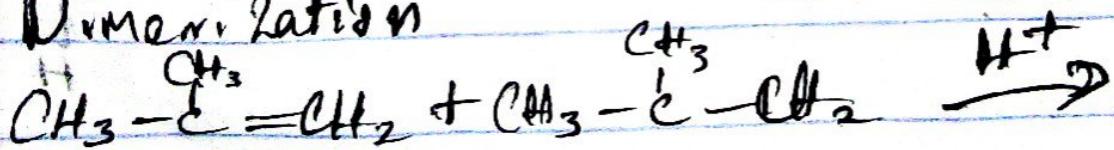
Reactivity \Rightarrow Alkyne $>$ alkene $>$ alkane

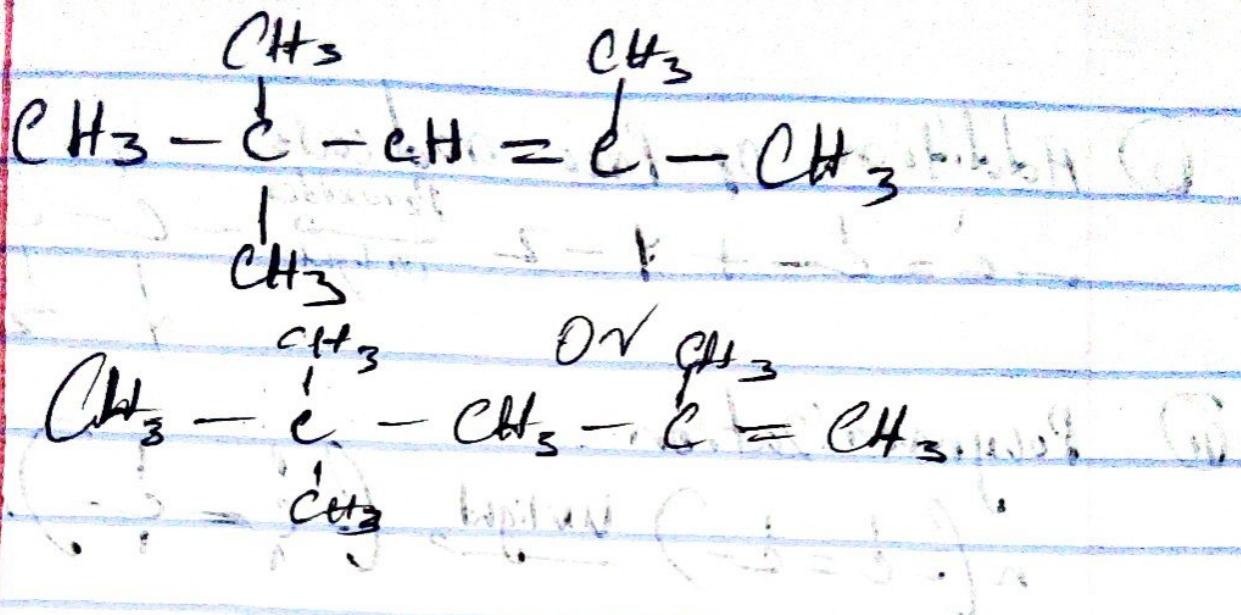
Stability \Rightarrow Alkene $>$ Alkyne $>$ alkane

③ Halohydrin formation

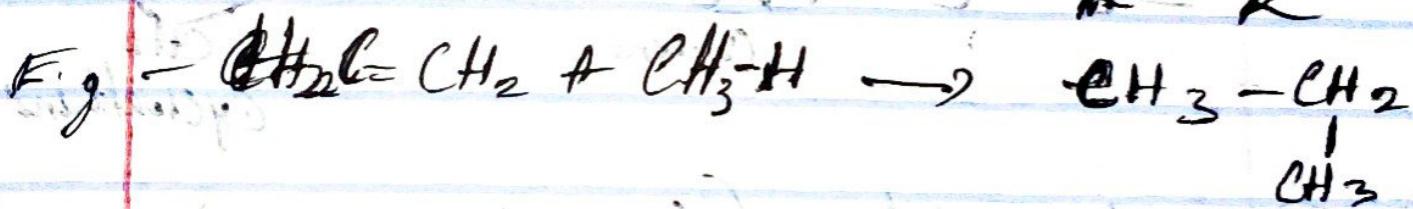
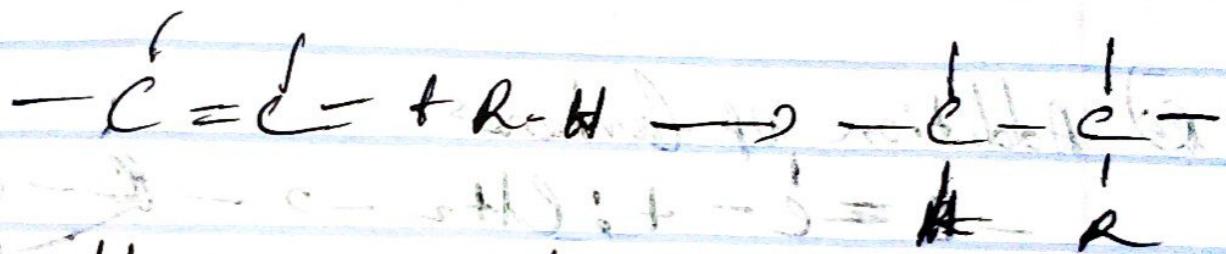


④ Polymerization

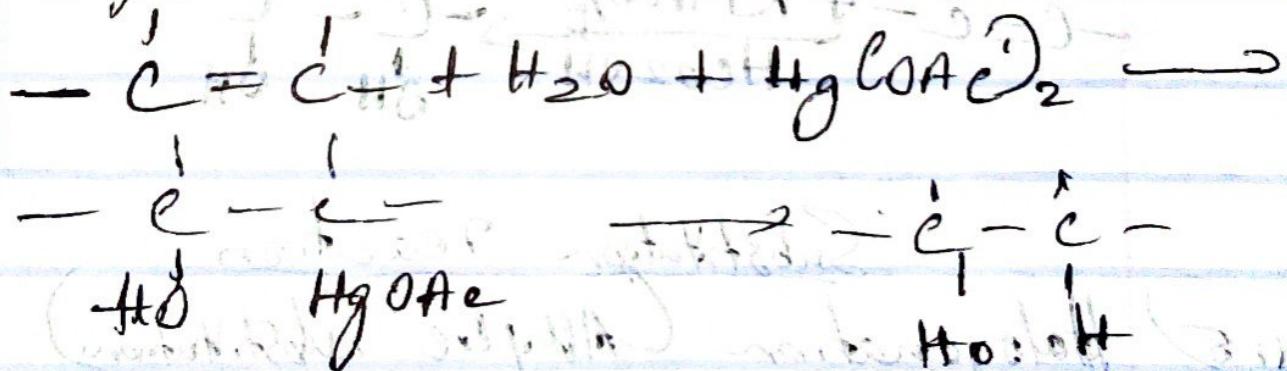




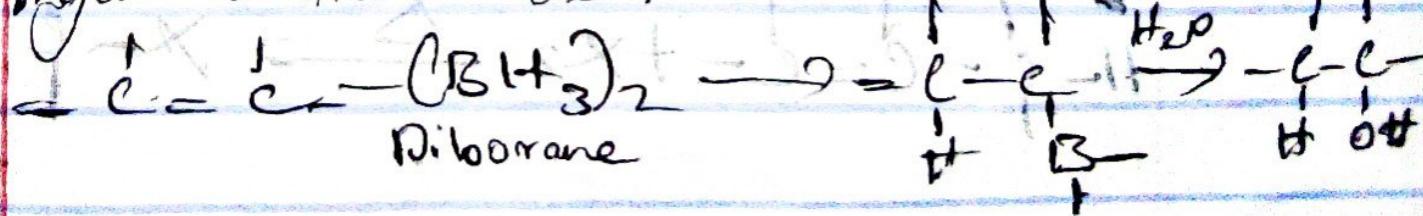
④ Alkylation



⑤ Oxidation & Reduction - Isomerization

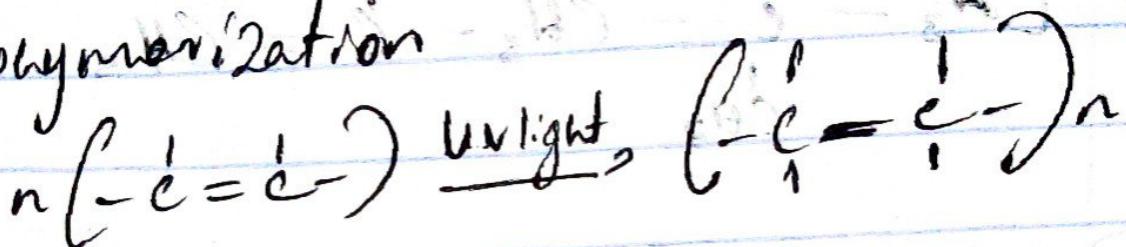


⑥ Hydroboration - Oxidation



D) Addition of free radicals

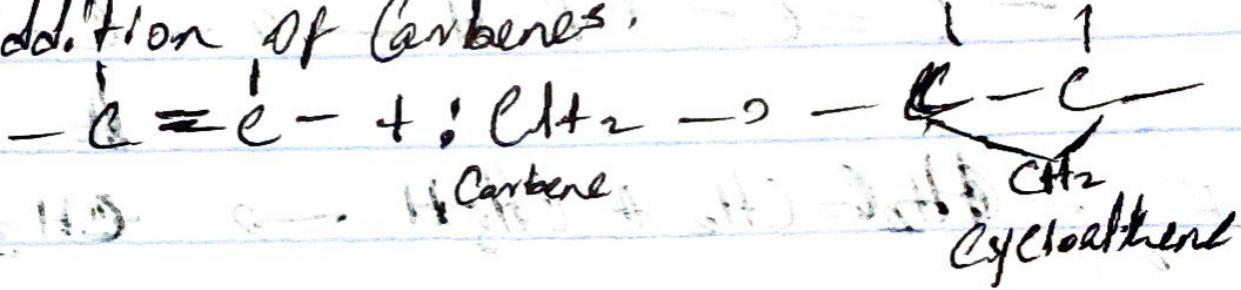
⑩ Polymerization



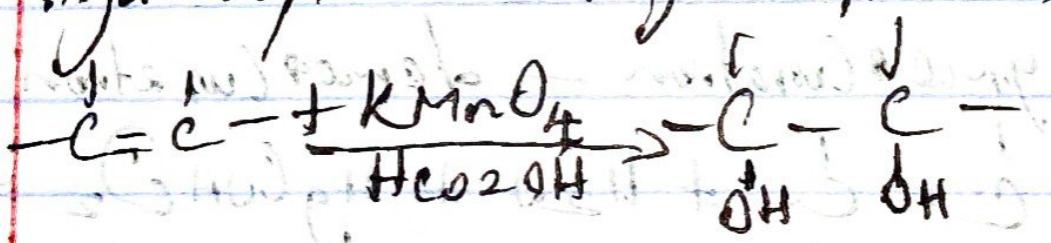
Ethan

Polyethylene

(ii) Addition of Carbenes

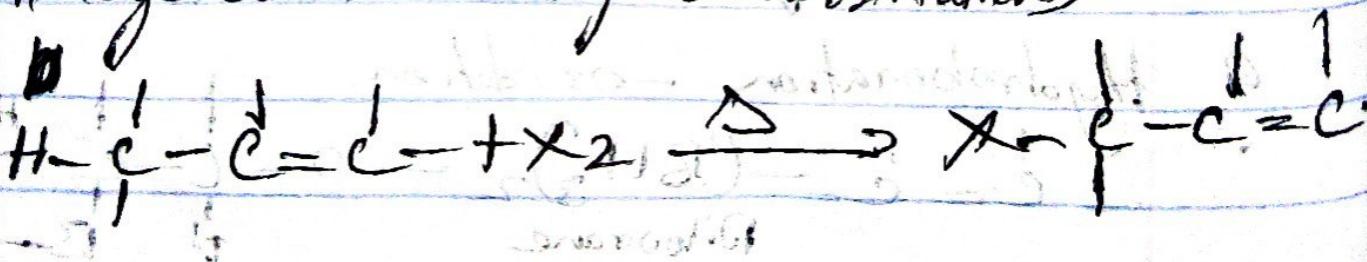


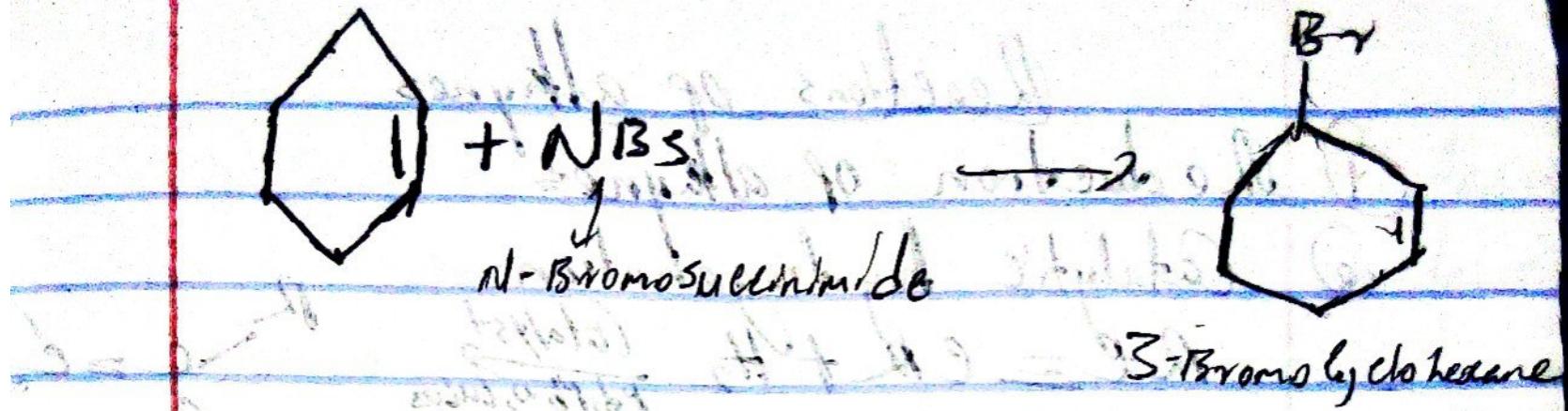
③ Hydroxylation (Glycol formation)



Substitution Reaction

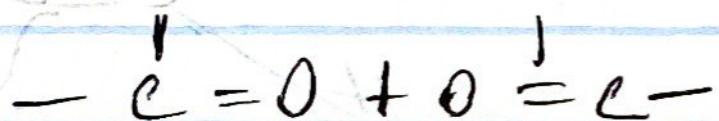
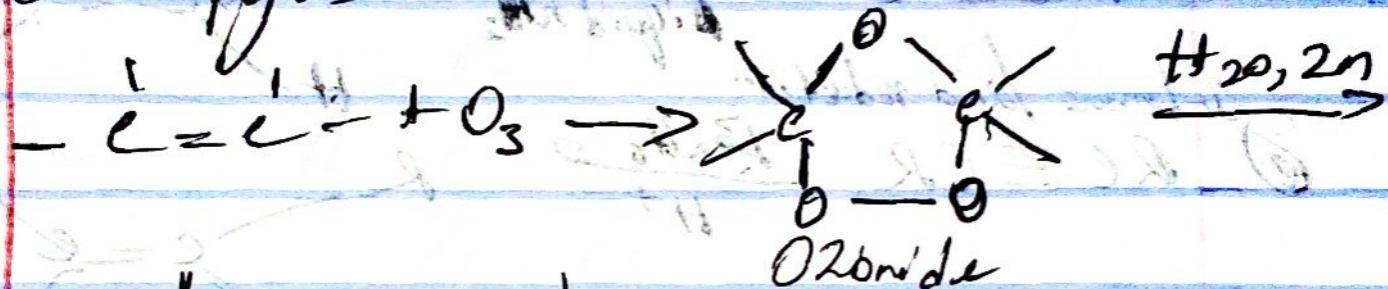
(16) Halogenation (Alkylic Substitution)





(b) Cleavage Reaction

Ozoneysis

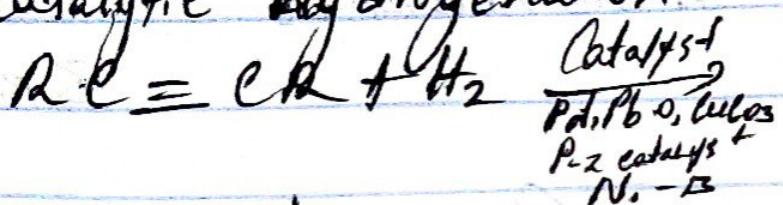


Aldehydes Ketones

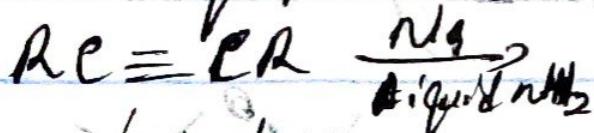
Reactions of alkynes

① Reduction of alkynes

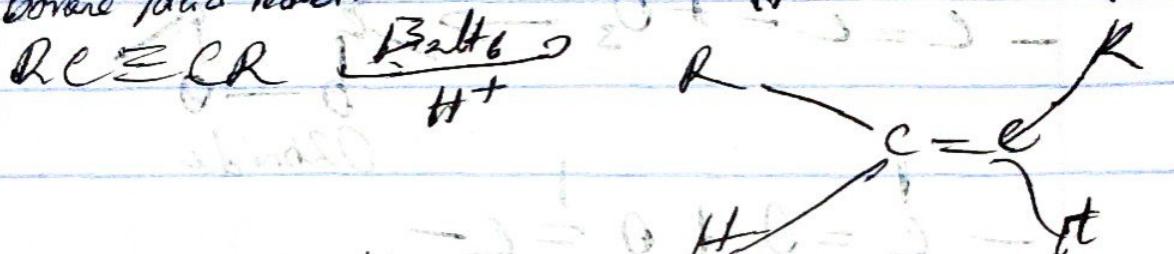
② Catalytic hydrogenation



③ Reduction in liquid ammonia

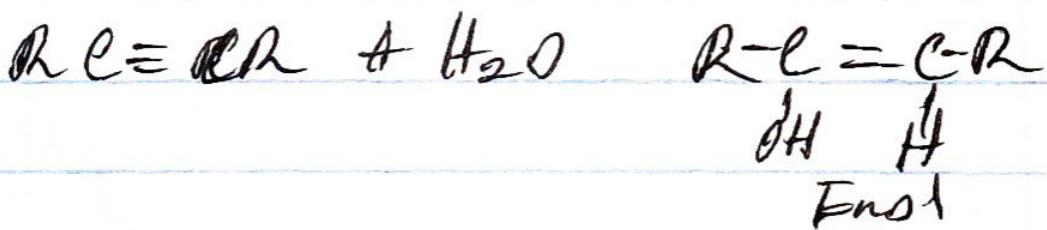


④ Borane acid reduction

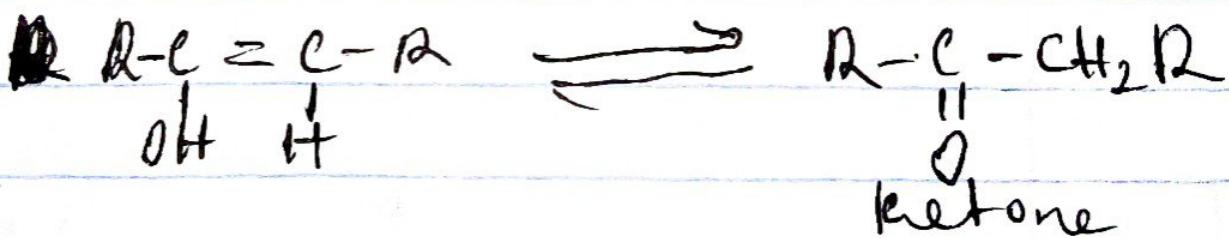


⑤ Cationic addition to alkynes (Hydration)

Step 1 Enol formation



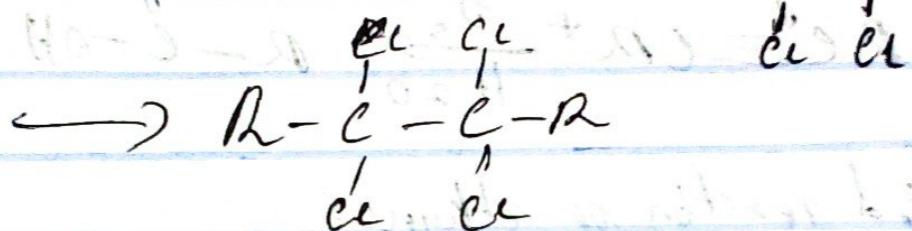
Step 2 Tautomerism



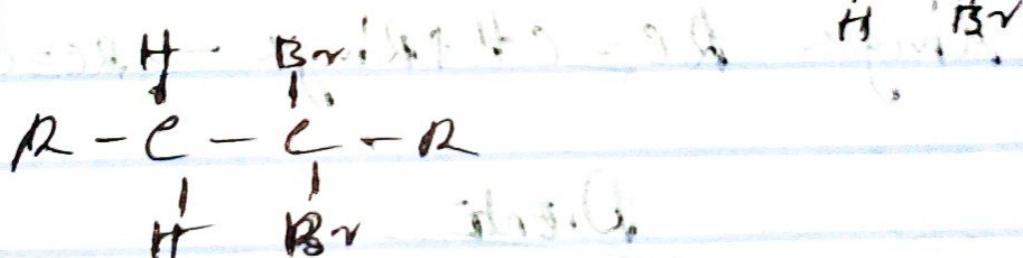
* Tautomerism is a phenomenon where a single chemical compound tends to exist in two or more

interconvertible structures that are different in terms of two relative position of one atomic nucleus which is generally the hydrogen.

(b) Halogenation



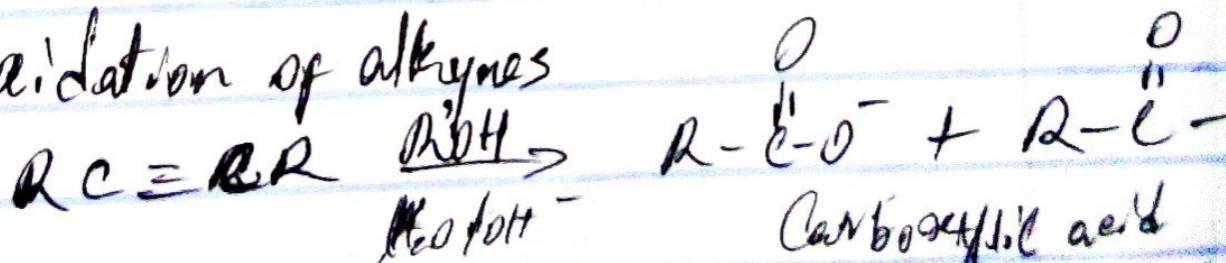
(c) Hydrohalogenation



* Germinal -

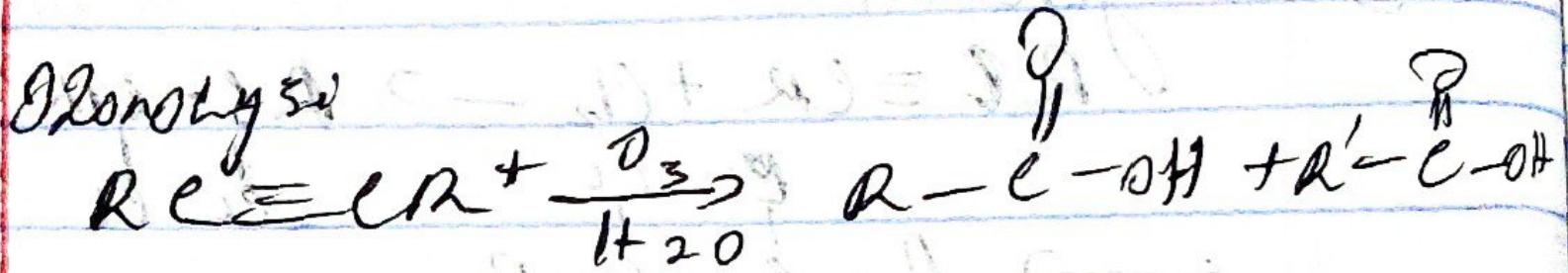
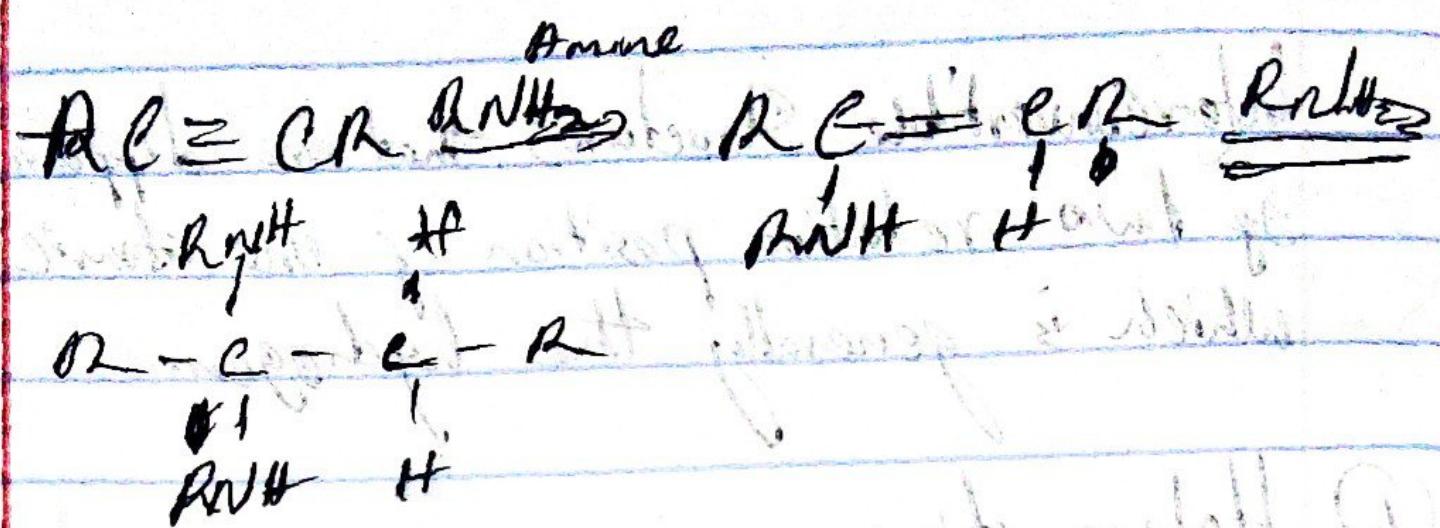
* Vicinal -

(d) Oxidation of alkynes



Permanganate
Oxidation

Carboxylic acid



⑥ Acid reaction of alkynes



Aromatic Hydrocarbon (Benzene C₆H₆)

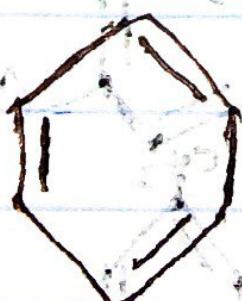
Aromatic hydrocarbons are unsaturated compounds that has a low degree of reactivity.

Aromaticity is the stability of the aromatic ring. Aromatic Compounds are unreactive. They are normally neutral in terms of reactivity.

Criteria for Aromaticity

- ① The molecule must be cyclic.
- ② The molecule must be fully conjugated.
- ③ The molecule must be planar (flat).
- ④ The aromatic system will contain $2n+2$ electrons where n is an integer.

$$2n+2e^- = \text{no. of electrons}$$



Benzene

discovered 1865

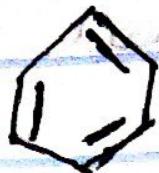
Name of some Arom.

Alkane

Structures

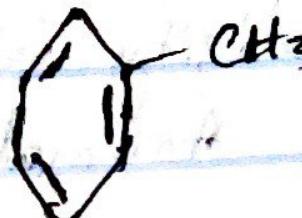
①

Benzene



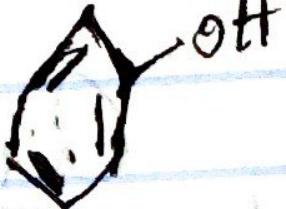
②

Toluene



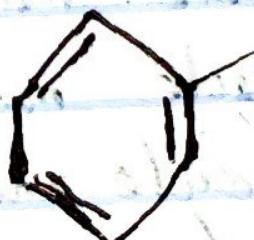
③

Pheno



④

Cumene



$\text{CH}(\text{CH}_3)_2$

⑤

Styrene



$\text{CH}=\text{CH}_2$

⑥

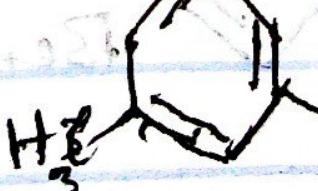
Xylyne



CH_3

⑦

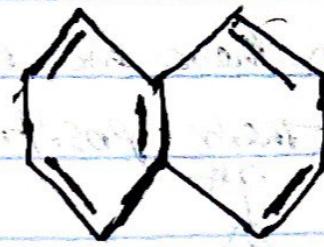
Mesitylene



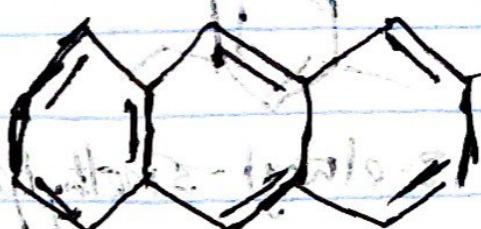
H_3C

CH_3

③ Naphthalene



④ Anthracene



Nomenclature of Aromatic Compounds

We use ortho - o-, meta m-, para p-

(ortho) o

(meta) m

2 (ortho)

3 (meta)

4 (para)

* = reference
substitution

o-bromonitrobenzene

m-nitrotoluene

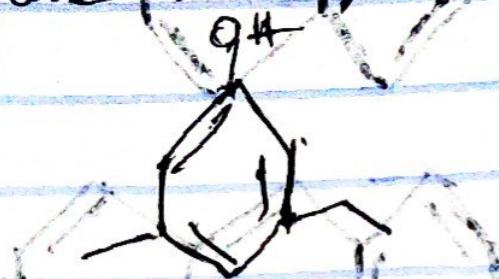
CH = CH₂



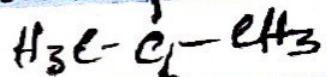
p-Chlorostyrene

- When there are more than 2 substituents, we use their position number +

cg



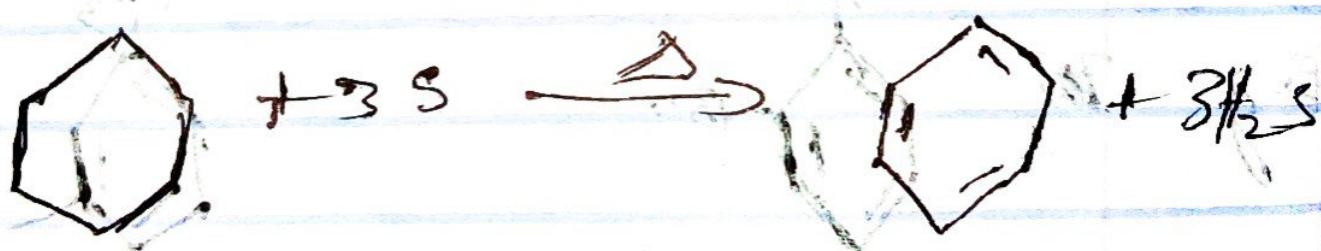
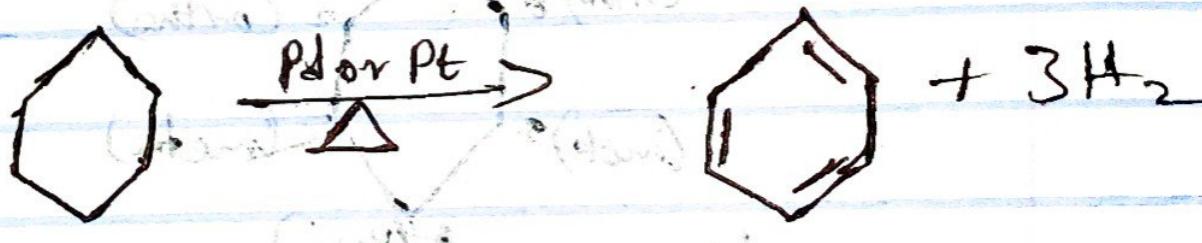
3-ethyl-5-methylphenol



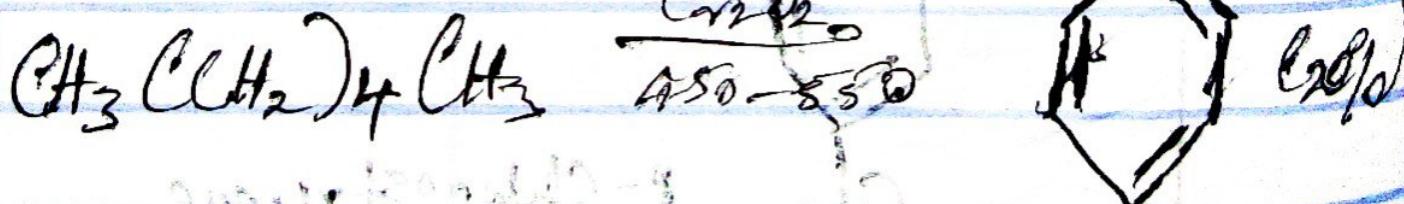
3,5-di-hydroxytoluene

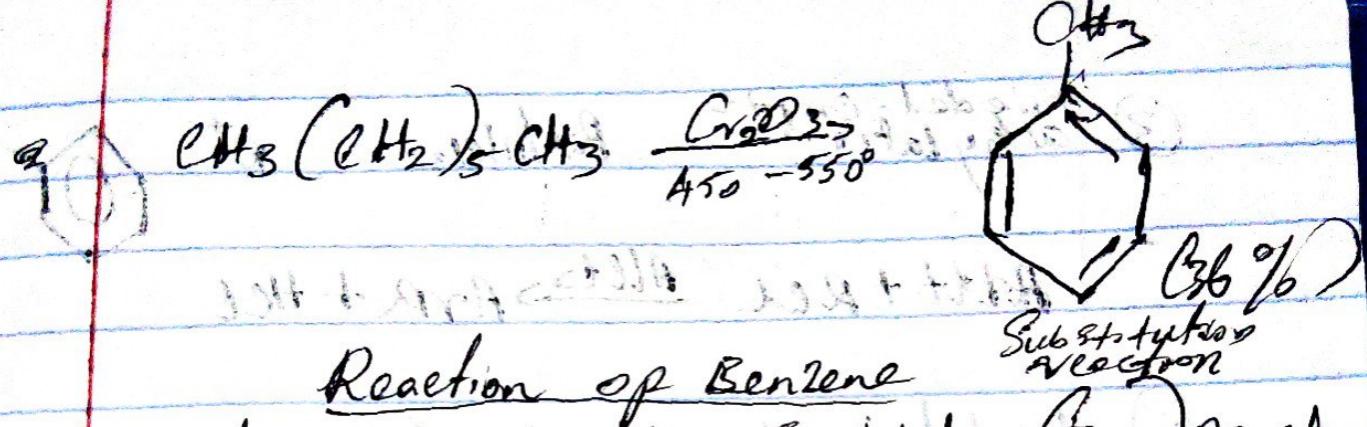
Ques. 3. Preparation of Benzene

① Dehydrogenation of Cyclohexane



② Dehydrogenation with Cyclization of Compounds



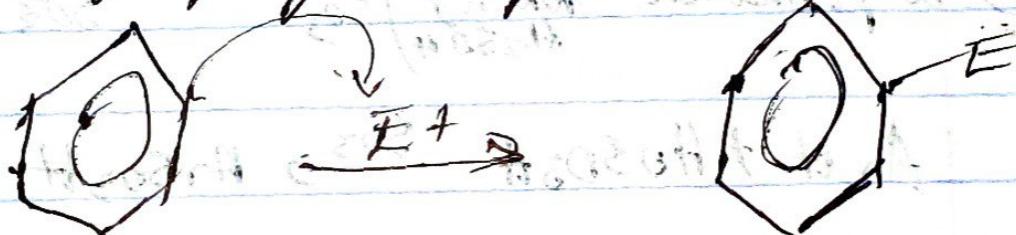


Reaction of Benzene

Substitution reaction

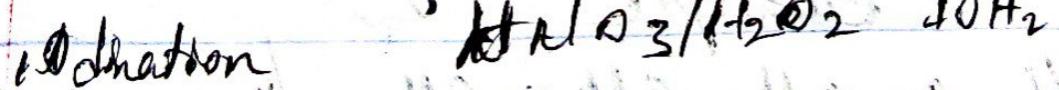
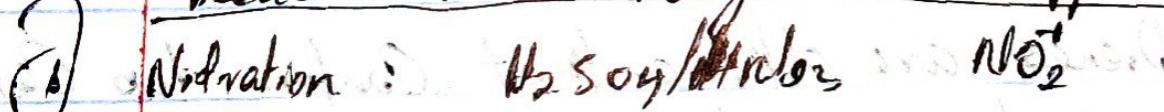
① Electrophilic Aromatic Substitution (EAS) Reaction

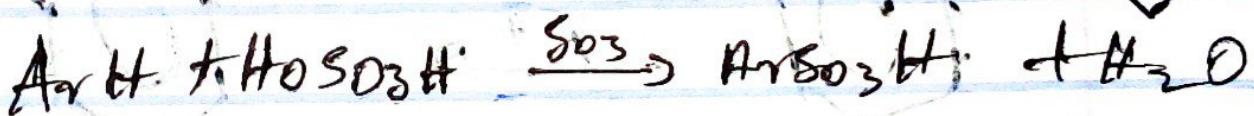
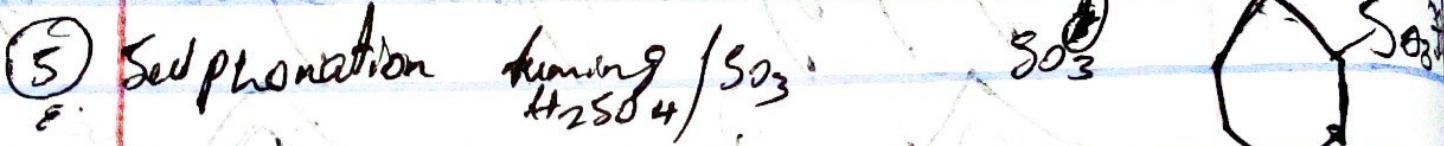
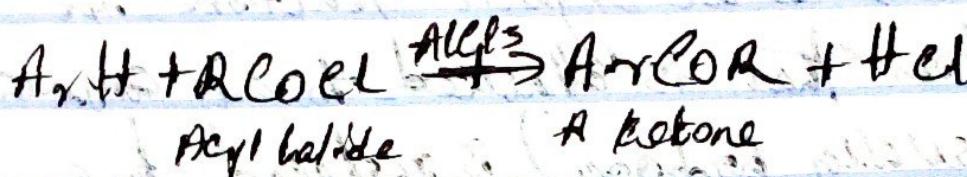
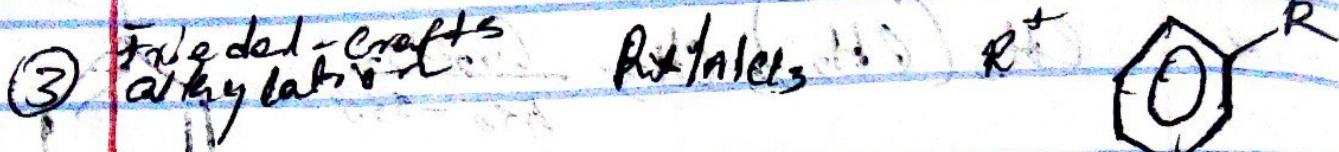
This is an organic reaction in which an atom that is attached to an aromatic system (usually hydrogen) is replaced by an electrophile



6 key reaction of Electrophilic Aromatic Substitution

Reaction Reagent Electrophile Product

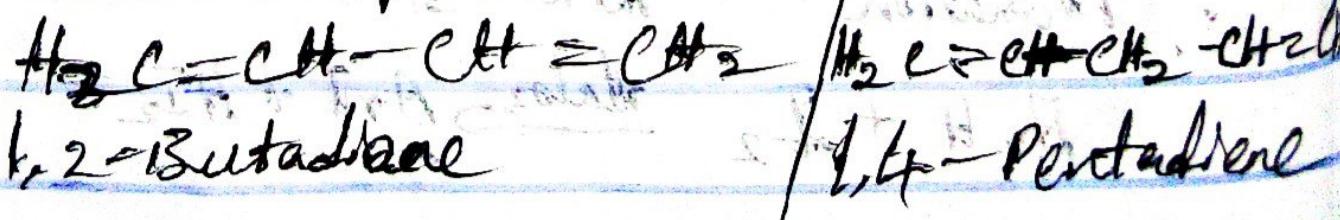




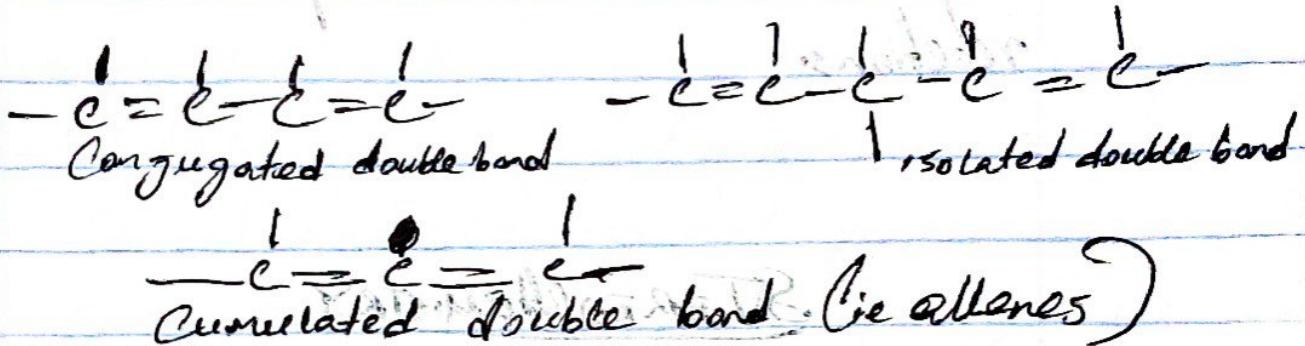
DIENE

Dienes are alkenes that contain two carbon-carbon double bonds and have essentially the same properties as alkenes. They have the same general formula as alkynes ($\text{C}_{n+2}\text{H}_{2n-2}$).

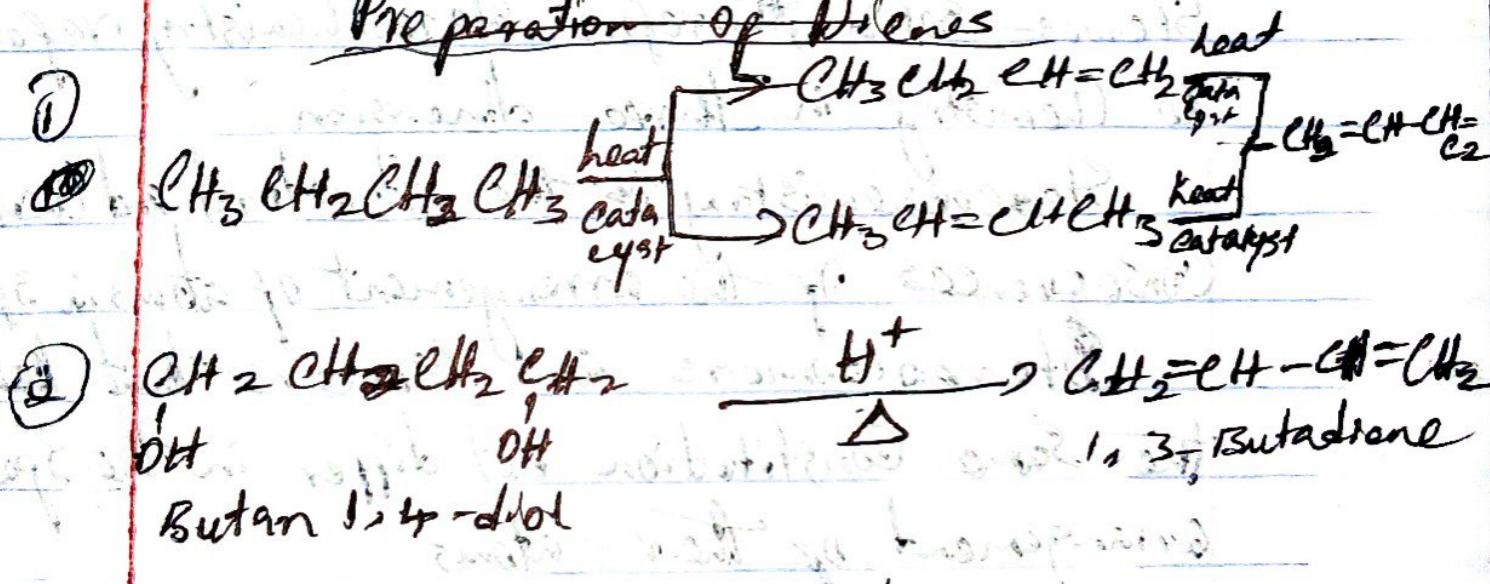
Example:



- Dienes are divided into two important classes according to the arrangement of the double bonds.
- * Conjugated double bond - when 2 double bonds are separated by one single bond.
 - * Isolated double bond - when 2 double bonds are separated by 2 or more single bonds.
 - * Cumulated double bond - when there is no bond between 2 double bonds.



Preparation of Dienes



Properties of Dienes

The chemical properties of a diene depends upon the arrangement of its double bonds.

- Isolated double bond has little effect on each other.
- Chemical properties of non-conjugated dienes are identical with those of simple alkenes.

Conjugated dienes differs from simple dienes in 3 ways

- (1) They are more stable.
- (2) They undergo 1,4-addition reaction.
- (3) They are more reactive in free radical addition reactions.

Stereochemistry

Stereochemistry is coin from a greek word Stereo - solid, therefore Stereochemistry refers to Chemistry in three dimension.

Stereochemistry is the structural and chemical consequences of the arrangement of atoms in 3D space.
Stereoisomers are isomers that have the same constitution but differ in the spatial arrangement of their atoms.

- Isomers is the phenomenon in which more than one compound has the same chemical formula but different chemical structures.
- Isomers are chemical compounds that have

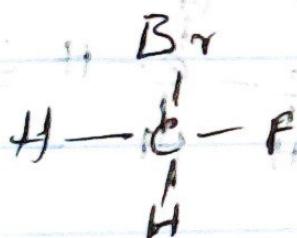
Identical Chemical formula but different chemical structures.

CHIRAL and ACHIRAL

Chiral is derived from the Greek word "Chir" meaning hand, this refers to handedness of molecules. If an object is not Chiral it is Achiral.

Chiral molecules does not possess an element of symmetry and are not superimposable on its mirror image.

Eg



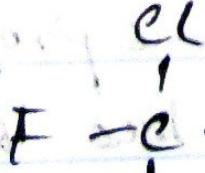
Since it is non-divisible and the compound is not superimposed it is a chiral compound.

Bromo Fluoromethane example is

* A Chiral Carbon is bonded to 4 different atoms

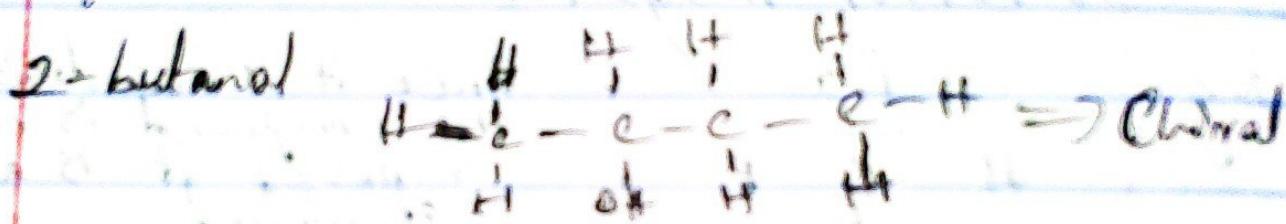
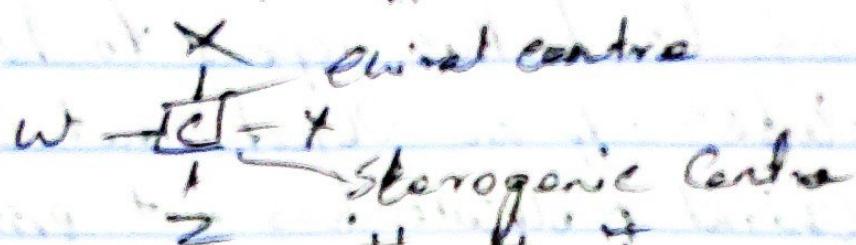
- AChiral molecules possesses an element of symmetry and are superimposable on its mirror image.

Eg



Chlorodifluoromethane is an achiral Compound

- Stereogenic Centre also known as Stereogenic Carbon or Chiral centre - This refers to the Carbon atom in an organic compound bonded to 4 different atoms.



- Line of Symmetry: This is a line that divides an organic compound into two equal parts
- * Chiral Compounds do not contain line of symmetry nor centre of symmetry.

Properties of Chiral molecule

- ② Chiral molecules have the same properties especially physical properties like MP, BP etc. are the same.



ELITE MEDIA NETWORK

**It won't be easy, but it will be worth it.
“Successful people do what unsuccessful
people are not willing to do. Don't wish it
were easier; wish you were better.”**

**For business advertisement, event
promotion, Examination past questions
and complete Lecture notes send a DM to
08164824018.**

First class is possible



OKWUDILI EMMANUEL
Founder, EliteMedia