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Engineering Chemistry-I (BS-109)

Basic Concepts of Organic Chemistry

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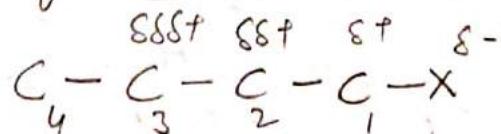
UNIT 3 - Basic Concepts of Organic Chemistry

Organic chemistry is the study of the structure, properties, composition, reactions, and preparation of carbon-containing compounds. Most organic compounds contain carbon and hydrogen, but they may also include other elements such as N, O, halogens, P, S, etc.

Organic compounds are formed by covalent bonds which are greatly affected by the various electronic displacements in between the covalent bonds, producing a great impact on the reactivity of the molecule. Different electronic factors that influence organic reactions are:

- (1) Inductive effect. (2) Electromeric effect. (3) Resonance or mesomeric effect. (4) Hyperconjugation.

(1) INDUCTIVE EFFECT: When an electron-releasing or electron-withdrawing species is introduced to a carbon chain, there is a displacement of σ electrons along a saturated carbon chain. This effect weakens steadily with increasing distance from substituent (EWG or EDG) and actually becomes negligible after three carbon atoms.

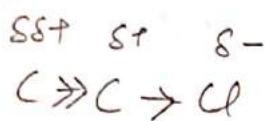


→ Inductive effect is due to polarization of σ bonds within a molecule.

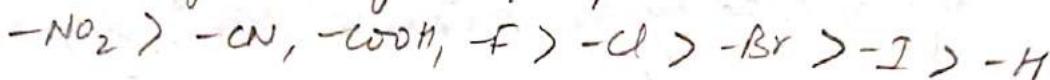
→ It is a permanent state of polarization.

→ There are 2 types of inductive effects :

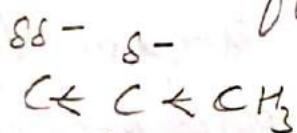
- (a). -I effect : If the substituent attached to the end of C-chain is electron withdrawing, the effect is called -I effect. In this, the σ electrons of the C-X bond are attracted by or displaced towards the more electronegative EWG.



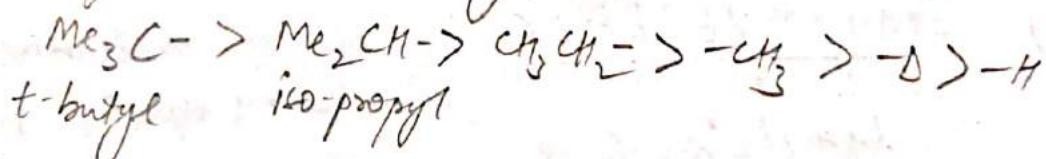
The -I effect of some of the groups is :



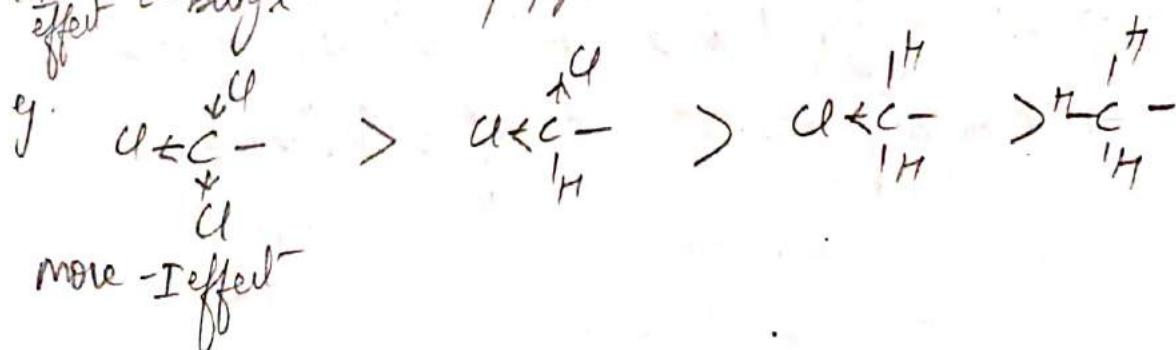
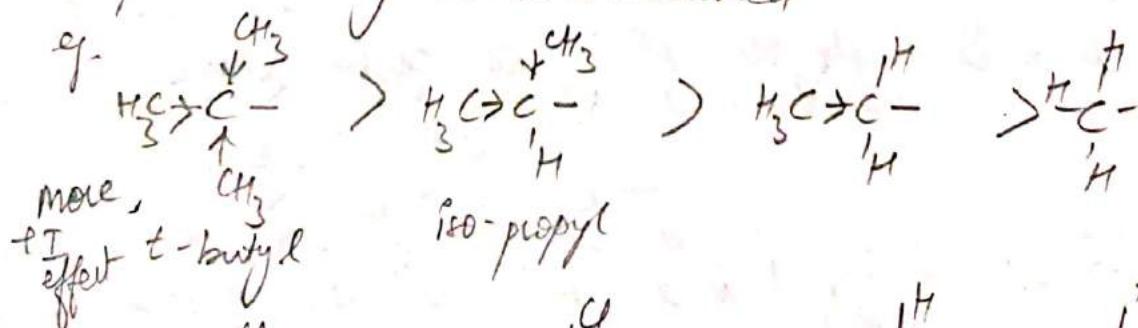
- (b) +I effect : If the substituent attached at the end of C-chain is electron-donating, the effect is called +I effect.



The +I effect exhibited by :

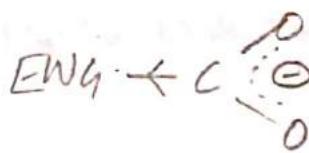


- More the number of EDG or EWG, more is the I effect experienced by C-atom attached.

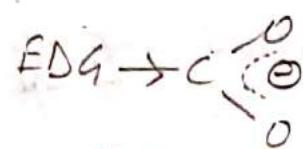


→ Inductive effect also affects the acidity and basicity of compds.
In general, EWG increase the acidity and EDG decrease it.

e.g.

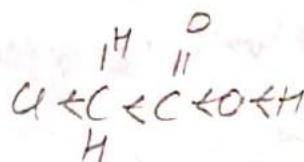


EWG stabilizes the COO^-

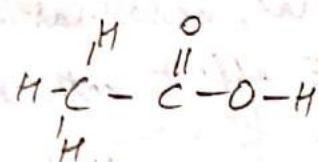


EDG destabilizes the COO^-

→ chloroacetic acid is more acidic than acetic acid.

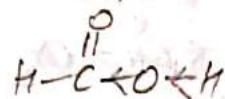
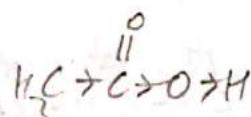


due to -I effect of -Cl,
release of H is much
easier ($k_a = 1.55 \times 10^{-3}$)

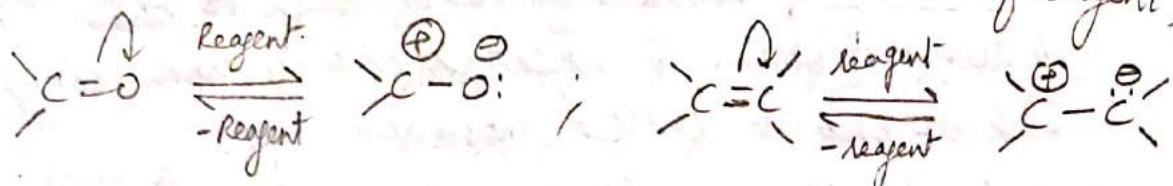


$$(k_a = 1.85 \times 10^{-5})$$

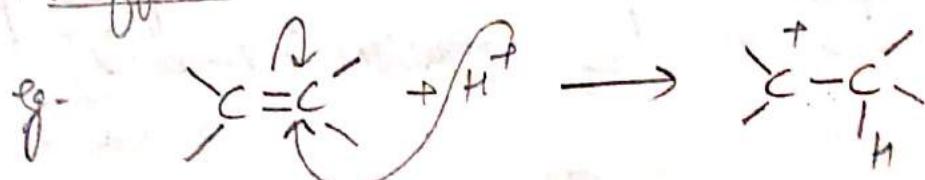
→ Acetic acid is weaker than formic acid due to +I effect



②. ELECTROMERIC EFFECT: It is an intramolecular (E effect) movement of electrons from a π bond to another atom in the molecule in presence of an attacking reagent. This is temporary and reversible (after the removal of reagent)

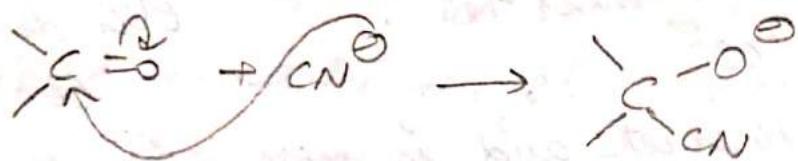


→ If the π -electrons of the multiple bond are transferred to that atom to which the reagent gets attached, it is called +E effect



→ If the π -electrons of the multiple bond are transferred to the atom to which the attacking reagent does not get attached, it is called $-E$ effect.

e.g.



In general, unsaturated system shows $+E$ effect with electrophiles and $-E$ effect with nucleophiles.

→ If a group attached to multiple bonded C-atom having $+I$ or $-I$ effect, it affects the dirⁿ of E effect directly.

e.g.



③ RESONANCE or MESOMERIC EFFECT : (Delocalization of π -e's)

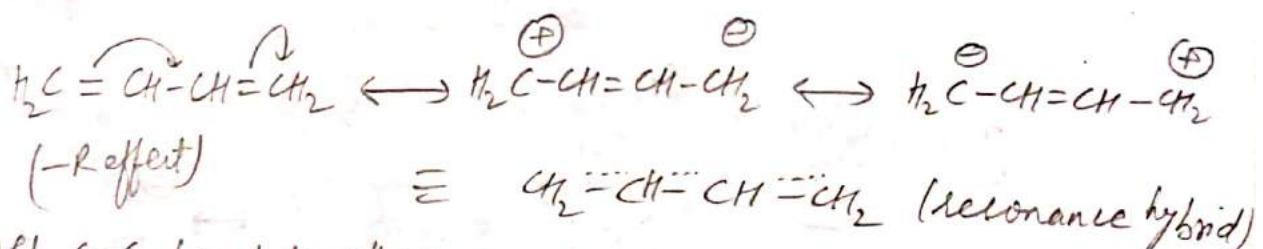
The permanent polarization of a group conjugated with a π -bond or a set of alternate π -bonds is transmitted through delocalization of the π -electrons of the system, resulting in a different distribution of electrons in the unsaturated chain. This kind of electron distribution in unsaturated compounds conjugated with EDG or EWG is called mesomeric effect.

→ Delocalization may involve:

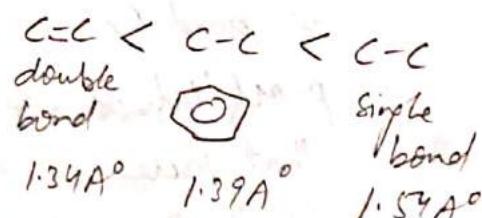
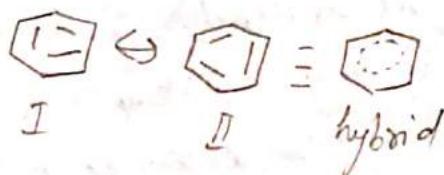
(i) π - π overlap (p-orbitals of π -bonded system are involved)

(ii) p- π overlap (atom's vacant or filled p-orbital with p-orbital in π -bond)

ii) π - π overlap: delocalization of π electrons occurs in conjugated system where π -bonds are separated by σ bonds only.
 e.g. buta-1,3-diene.

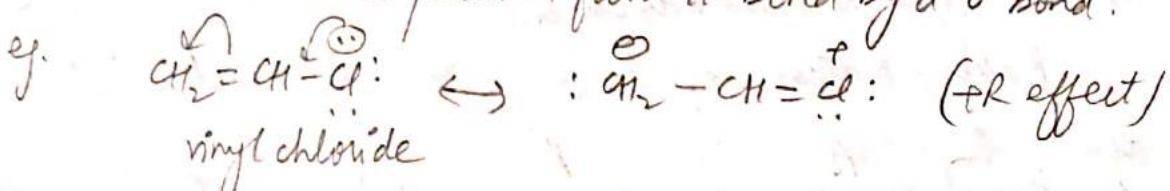


All C-C bond lengths are greater than that of double bond and smaller than that of single bond.
e.g. Benzene



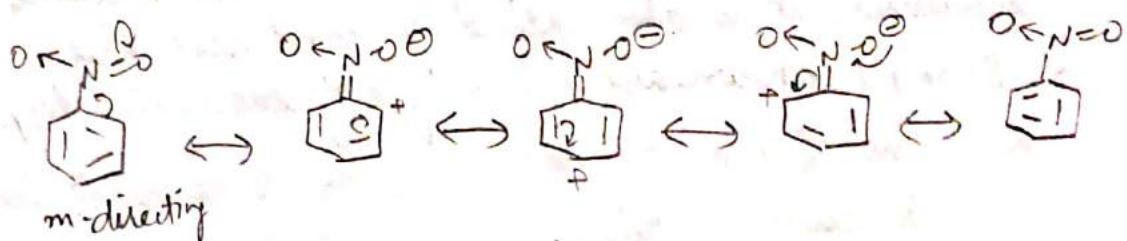
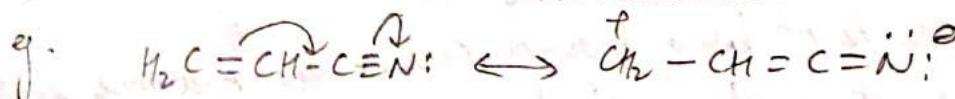
- More the number of resonating structures, more is the stability of the molecule.
 - Resonance hybrid is more stable than any contributing structures because delocalization lowers the energy.

(iii) P-π overlap: Where p-orbital of atom (vacant, or e⁻ or l.p.) is separated from π -bond by a σ bond.



- There are 2 types of R/M effects!

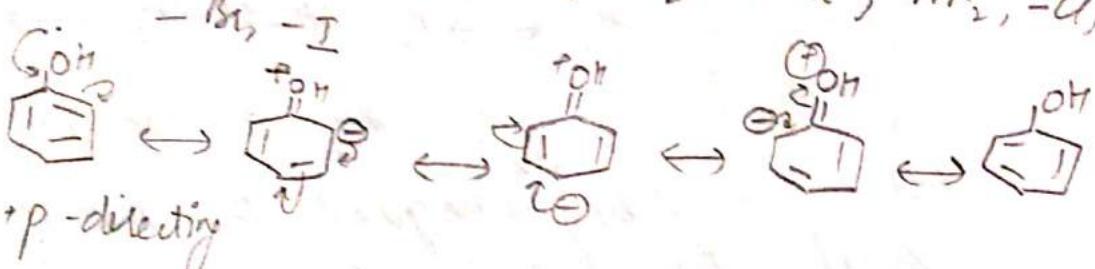
(ii). $-I$ or $-M$ effect: where the groups withdraw the electrons from the double bond or from a conjugated system towards themselves due to resonance.



e.g. C=O , $-\text{CHO}$, $-\text{COOR}$, $-\text{CN}$, $-\text{NO}_2$

iii) +R or +M effect: groups which donate electrons to the double bond or to a conjugated or aromatic system.

e.g. -OH, -OR, -SH, -SR, -NH₂, -NHR, -NR₂, -Cl, -Br, -I

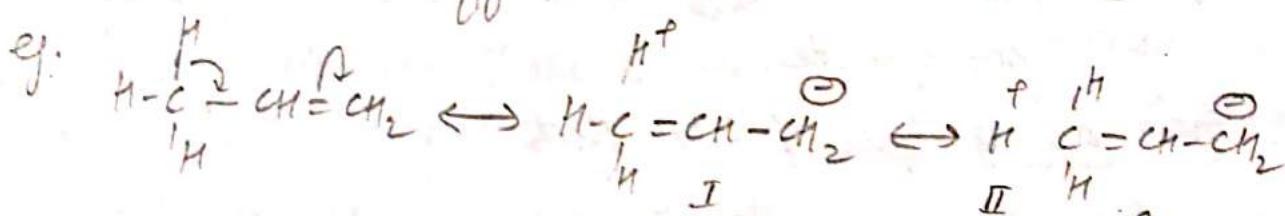
e.g. 

$\sigma + p$ -directive

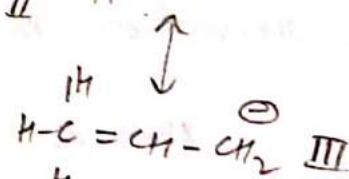
(4) HYPERCONJUGATION: It is the stabilizing interaction that results from the interaction of the electrons in a σ -bond ($C-H$ or $C-C$) with an adjacent empty or partially filled p -orbital or a π -orbital to give an extended molecular orbital that increases the stability of the system. In simple words, it is the delocalization of σ electrons through $\sigma-\pi$ or $\sigma-p$ orbitals.

→ It is similar to resonance, but is extended to σ -bonds

→ This effect is also known as Baker-Nathan effect.



I, II, III: hyperconjugative structures

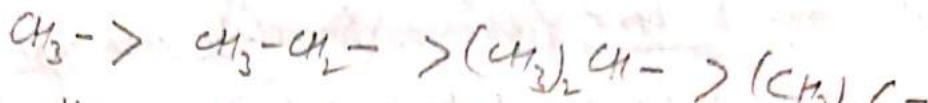


→ Since, there is no bond between carbon and A atoms in these structures, it is also called no-bond resonance.

→ Example shown above is a type of sacrificial hyperconjugation as no. of covalent bonds in structure during hyperconjugation < no. of covalent bonds in original structure

→ More the number of α -H-atoms (α -atom present on C next to double bond), more is the no. of such α -H atoms, more are the no. of hyperconjugative structures.

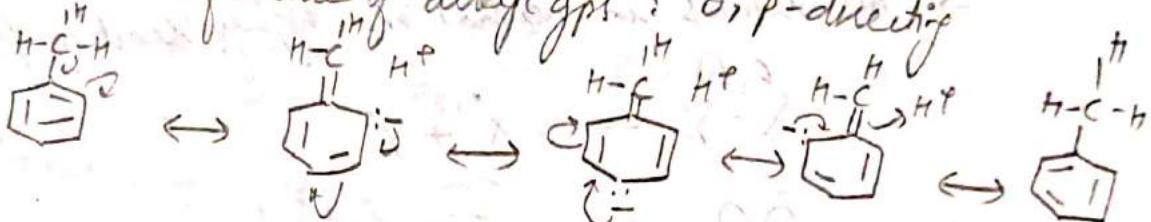
order of hyperconjugative effect decreases as:



→ In case of ethene, there is no hyperconjugation as there is no α -H atom $\text{H}_2\text{C}=\text{CH}_2$

→ Significance of hyperconjugation effect:

(1) Directive influence of alkyl groups: σ , ρ -directive

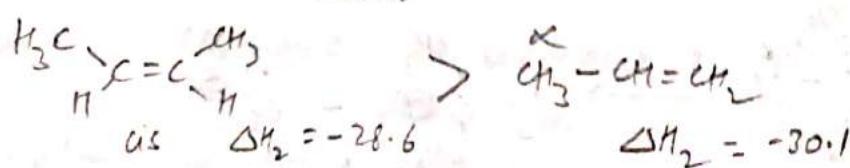
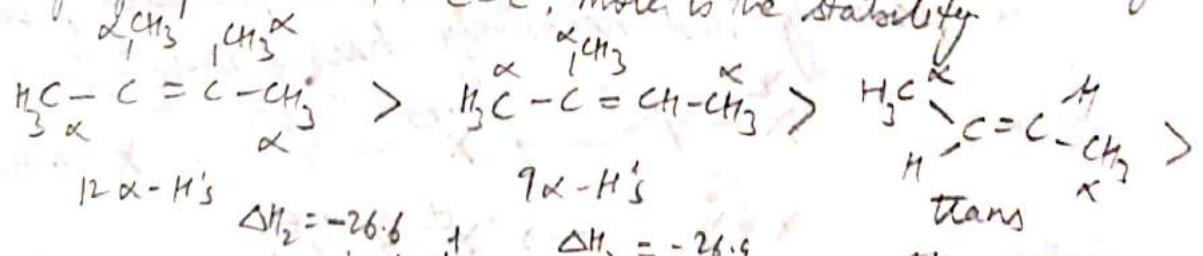


(2). Shortening of C-C adjacent to multiple bonds



(3). Relative stabilities of alkenes: Heat of hydrogenation (ΔH_{rxn})

alkyl groups attached to $\text{C}=\text{C}$, show that greater the no. of more is the stability.



(4). Stability of carbocations and free radicals.

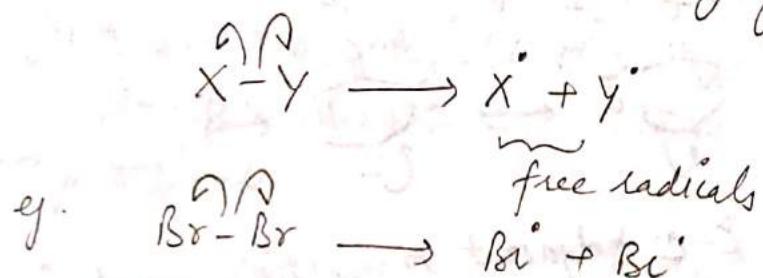
- Reactive Intermediates:

Organic reactions proceed by the rupture of covalent bonds and formation of new bonds. The bonds are broken in one of the two ways:

- (i). Homolytic bond fission or homolytic cleavage:

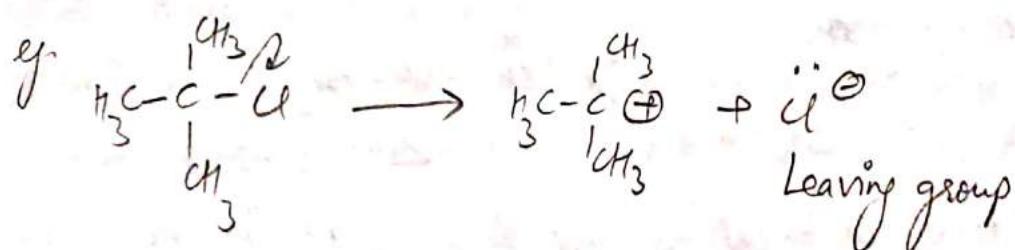
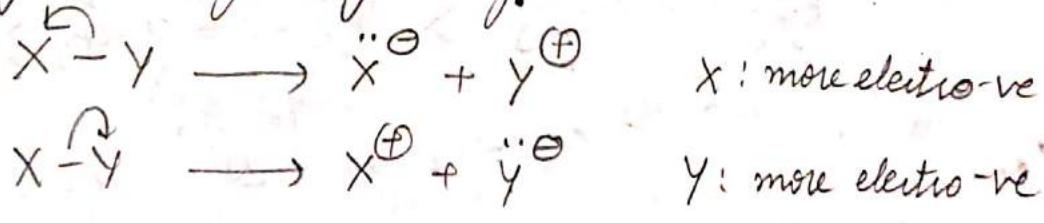
→ The covalent bond is broken symmetrically so that one electron of the bonding pair remains with each of the originally bonded atoms. In other words, the bond is broken symmetrically and each atom gets one electron.

→ This results in neutral and highly reactive free radicals



The shift of a single electron is represented by a fish hook arrow.

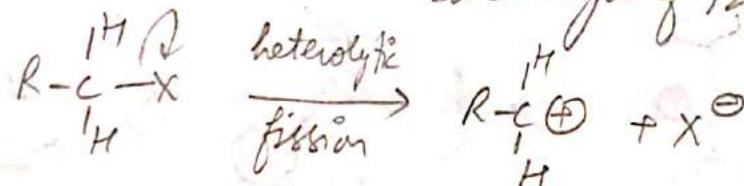
- (ii) Heterolytic cleavage: The shared pair of electron is taken away by one atom completely (relatively more electro-negative one). This results in the formation of charged species i.e. positively and negatively charged ions.



A full arrowhead denotes the shift of an electron pair.

→ Reactive intermediates are resultant of above 2 mentioned bond fissions. These intermediates are highly reactive and are of transitory existence and take part in the reaction as soon as they are formed.

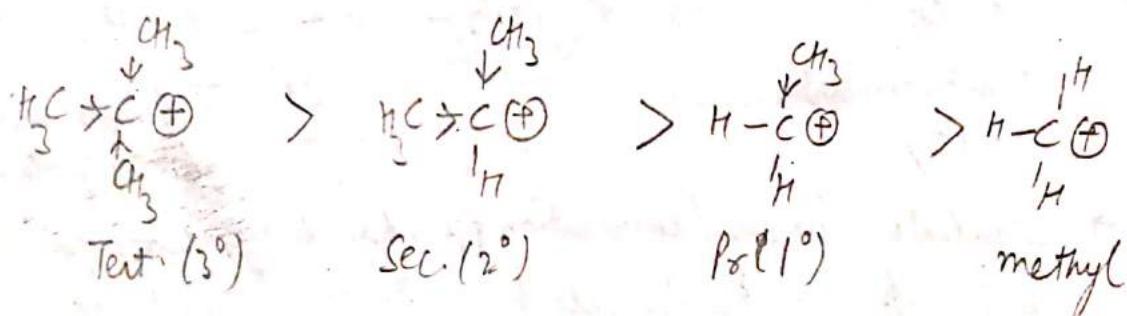
① CARBOCATIONS: It is defined as the carbon atom, which is trivalent, contains an even number of electrons and carries a positive charge ($\Rightarrow e^-$ deficient). It is sp^2 hybridized and has a trigonal planar structure with bond angle of 120° .



\rightarrow Stability of carbocations: $3^\circ > 2^\circ > 1^\circ$

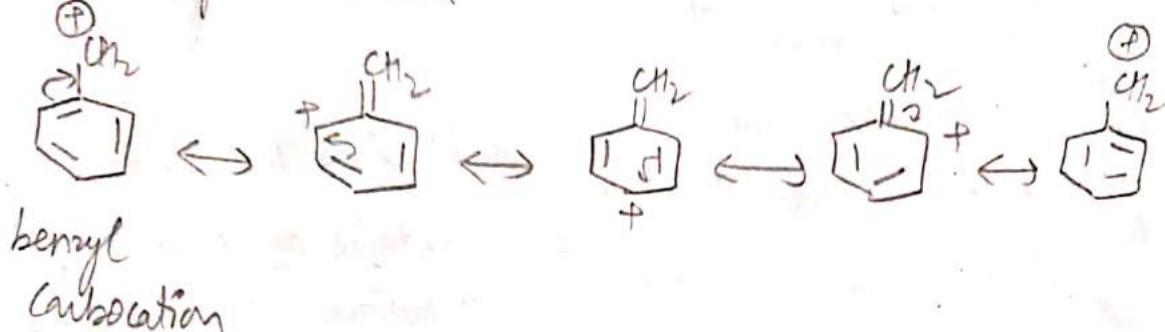
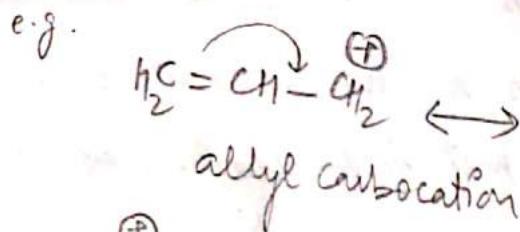
(a) Based on inductive effect.

If an EDG such as alkyl gp. is present adjacent to the carbon bearing positive charge, then the stability of carbocation π . This is so because EDG disperses the positive charge and stabilizes the carbocation.

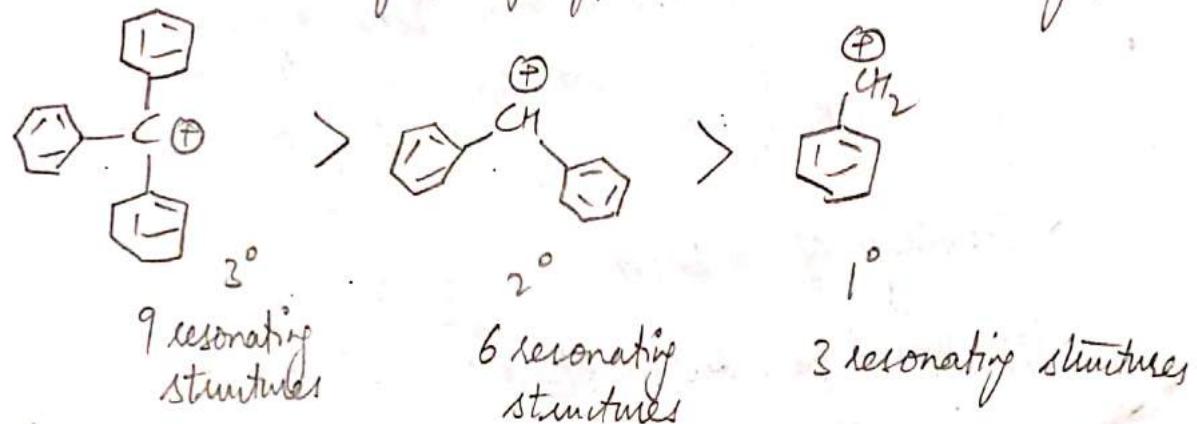


(b) Based on resonance: By resonance, the positive charge on the central C-atom gets dispersed over other C-atoms rendering stability to the carbocation.

→ The more the canonical structures for carbocation, more stable it will be.

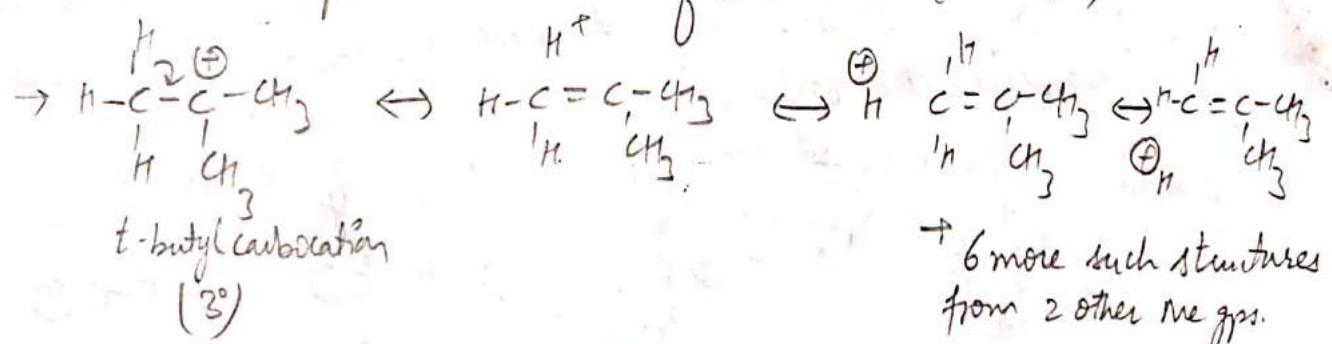


More the no. of phenyl groups, more is the stability.

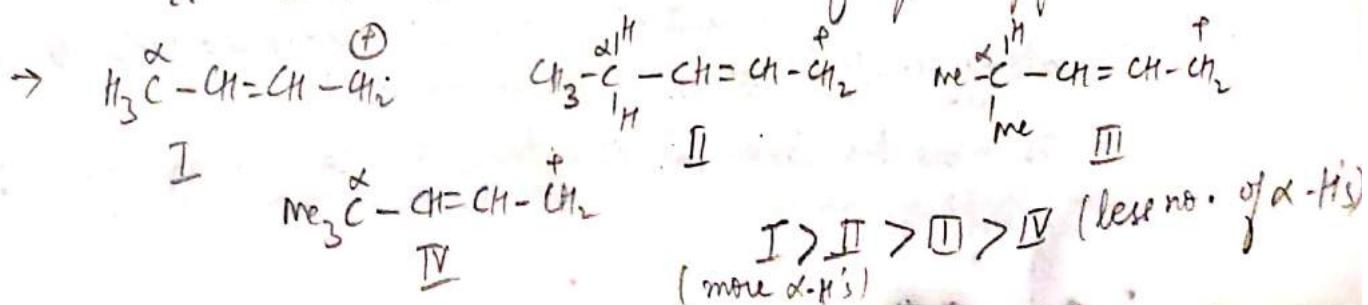


(i) Based on hyperconjugation effect:

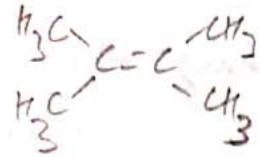
→ depends on the number of α -H atoms (ionizable)



→ Similarly, iso-propyl carbocation (2°) has 6 hyperconjugative structures while ethyl carbocation will have 3 such structures.
 $3^\circ > 2^\circ > 1^\circ$ (on the basis of hyperconjugation as well)



→ Highly substituted alkenes are more stable due to hyperconjugation

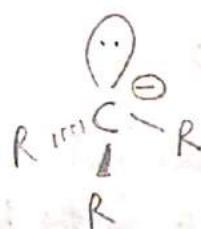


There are 12 ionizable H-atoms are present on the C-atoms adjacent to double bond

→ Overall order based on π double bond.

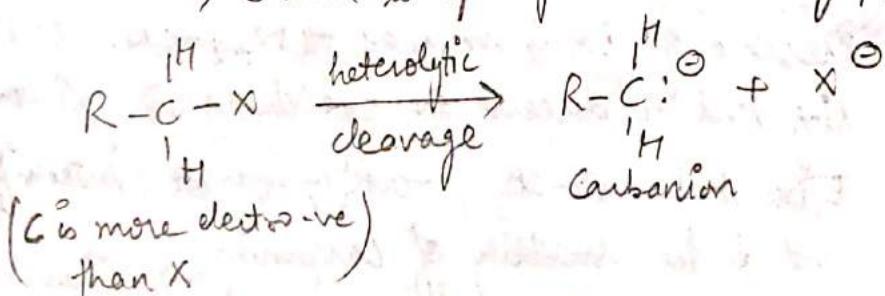
→ EDG such as $-CH_3$, $-OCH_3$, $-OH$ present on the benzene ring ↑ the stability while EDG such as $-NO_2$, $-CN$, $-COOR$, $-Cl$ ↓ the stability of carbocation.

⑪ CARBANIONS : It contains a trivalent carbon with a lone pair of e^- and carbon is negatively charged.



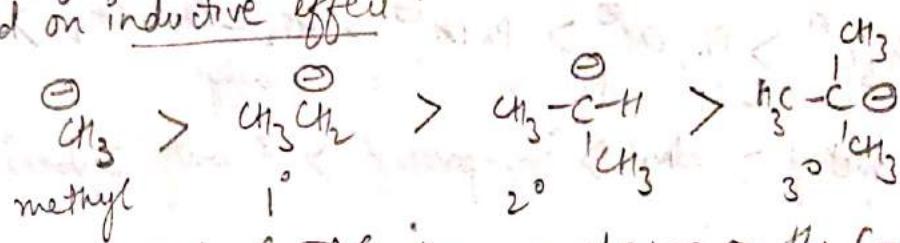
→ There are 8 e⁻ around C-atom and it is not e⁻ deficient

\rightarrow e⁻ deficient C-atom is sp³ hybridized exhibiting pyramidal geometry



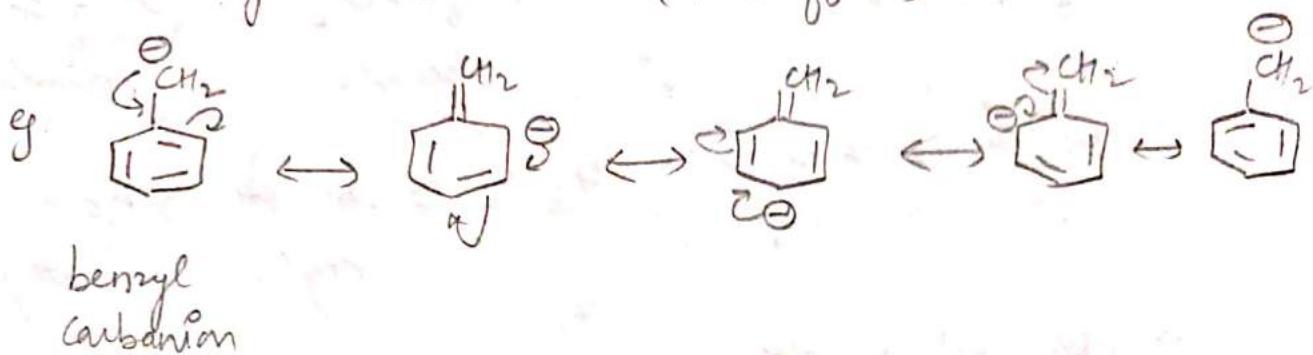
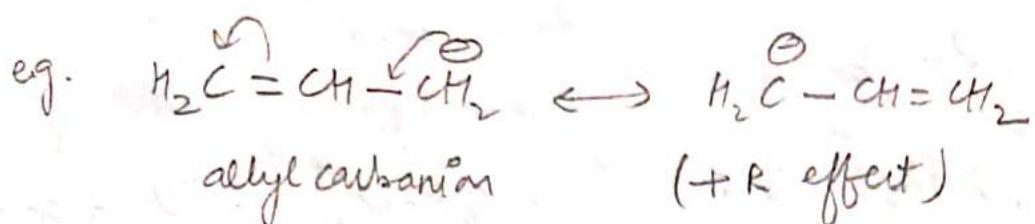
Stability of carbonions. $1^\circ > 2^\circ > 3^\circ$

(g). Based on inductive effect



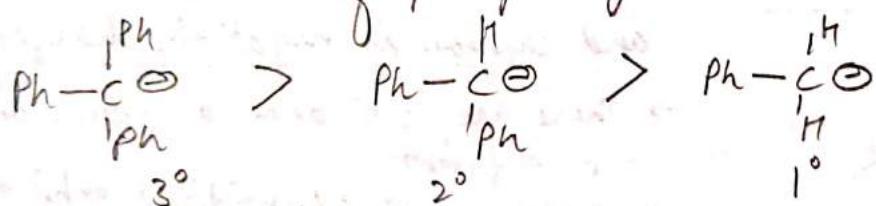
Due to $+I$ effect of EDG, the -ve charge on the C-atom intensifies making it less stable.

(b) Based on resonance: Stabilization is due to delocalization of the negative charge which is distributed over other carbon atoms.



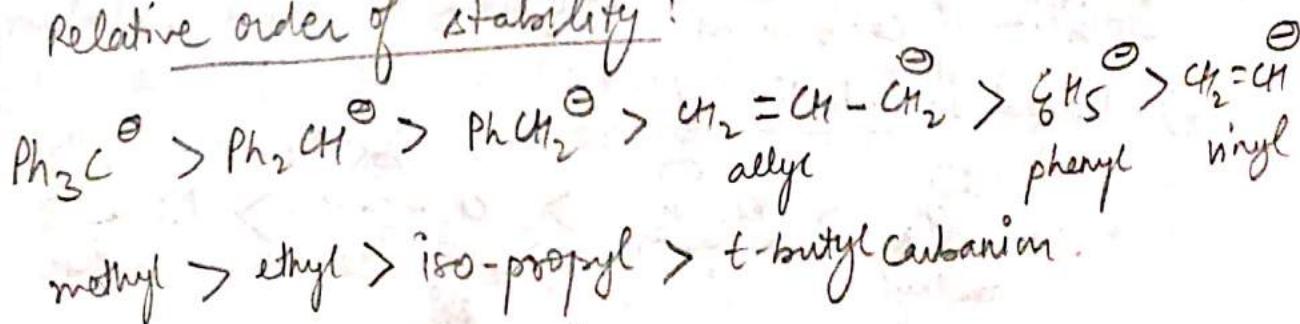
→ Benzyl cation is more stable than allyl cation due to more resonating structures.

→ More the number of phenyl rings, more is the stability



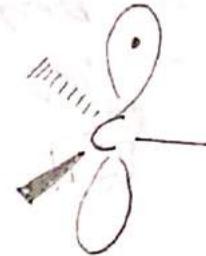
→ Presence of EWG such as $-NO_2$, $-CN$, $-Cl$ etc. in the benzene ring tend to disperse the $-ve$ charge, $\therefore \uparrow$ the stability, while EDG such as $-CH_3$, $-OCH_3$, $-OH$ etc. intensify the $-ve$ charge and \downarrow the stability of carbanion.

→ Relative order of stability!



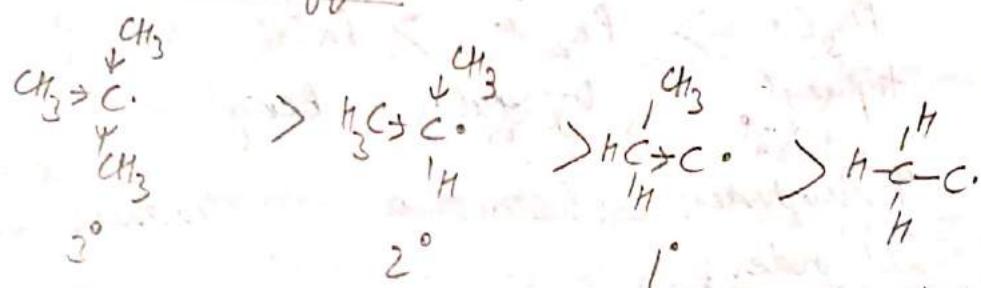
III. FREE RADICALS: They are the resultant of homolytic cleavage, in which the two fragments produced carry an unpaired electron (odd, single non-bonding) in which the two fragments produced carry an unpaired electron (odd, single non-bonding).

- They are highly reactive due to the tendency of the odd e⁻ to pair up with another available e⁻.
- They are sp² hybridized exhibiting planar geometry. They are trivalent, paramagnetic (due to odd e⁻) and contains 7e⁻ in outermost shell, ∴ e⁻ deficient.



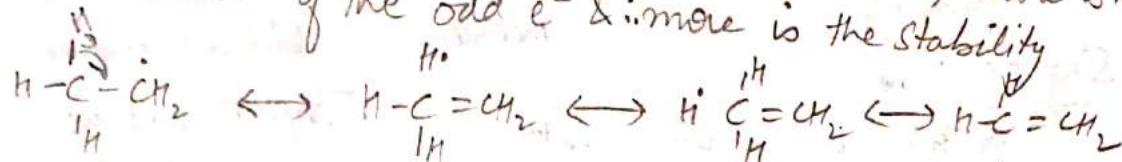
→ Stability Order : 3° > 2° > 1°. (Same as that in carbocations)

(a). Based on inductive effect :

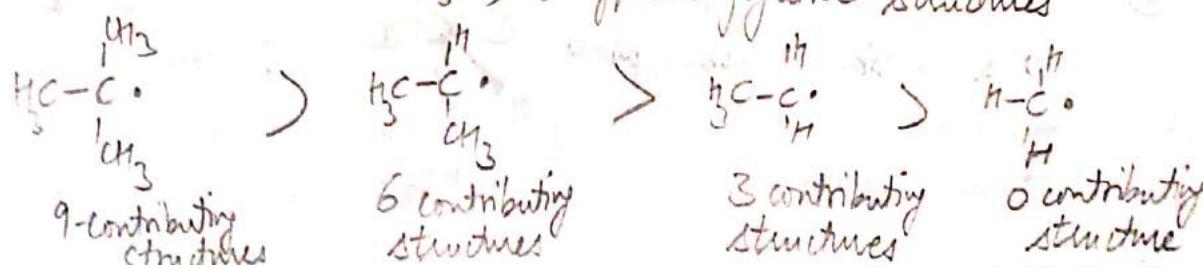


Free radicals are e⁻ deficient, so alkyl groups (PI effect) compensates for the e⁻ deficiency. More the alkyl groups, more the e⁻ donation, more stable is the radical.

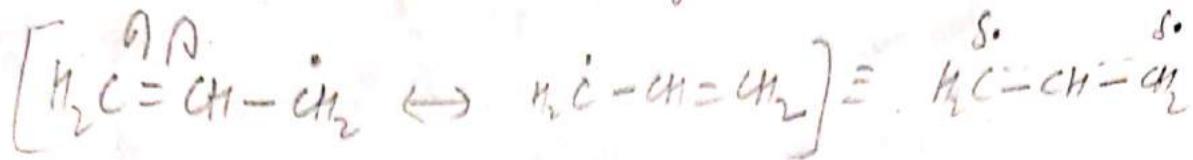
(b). Based on hyperconjugation : More the no. of alkyl groups attached to the radical C-atom, more is the delocalization of the odd e⁻ & more is the stability.



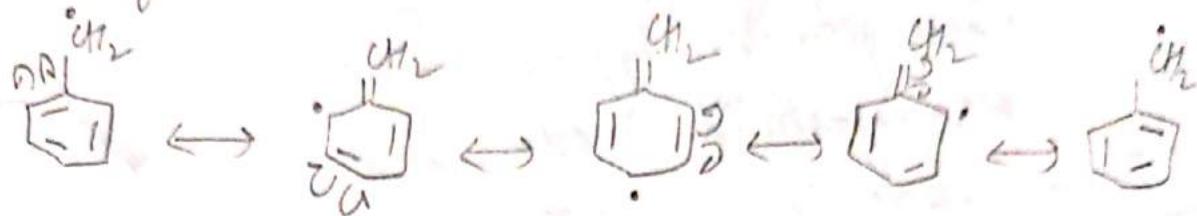
1-CH₃ ⇒ 3 hyperconjugative structures



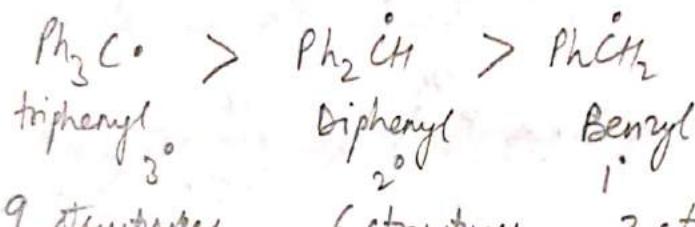
③ Based on resonance: Delocalization of unpaired e⁻ over the allyl radical π-orbital system.



e.g. benzyl radical



- Benzyl radical is more stable than allyl radical due to more number of resonance structures.
- More the number of phenyl rings attached to the carbon radical, more is the delocalization, hence more is the stability.

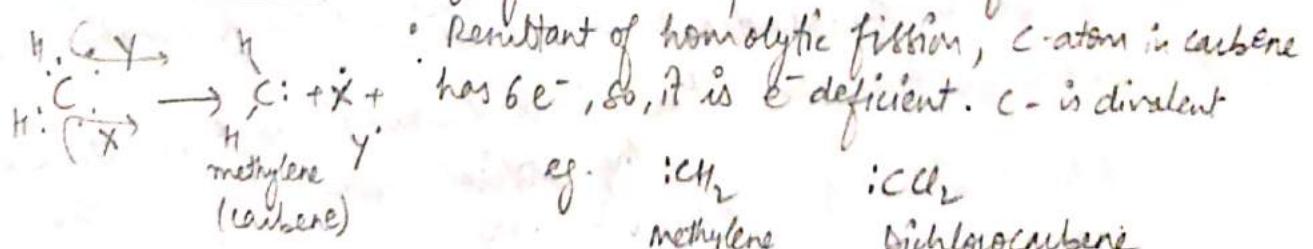


9 structures 6 structures 3 structures

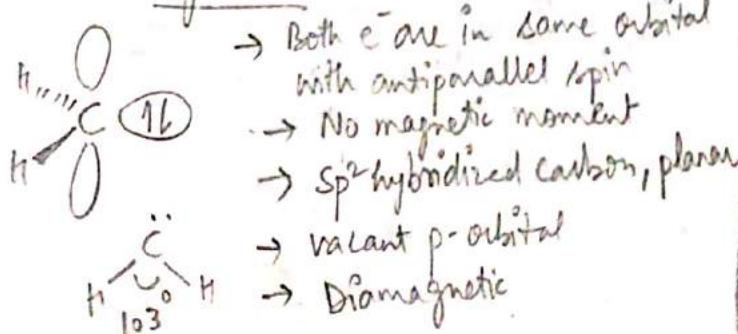
Overall order:



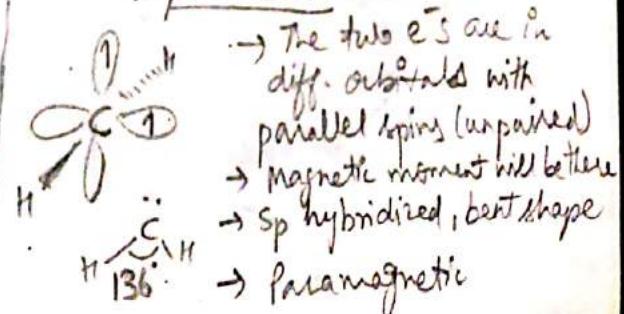
④ CARBENES: • Highly reactive species with a lifetime < 1 sec.



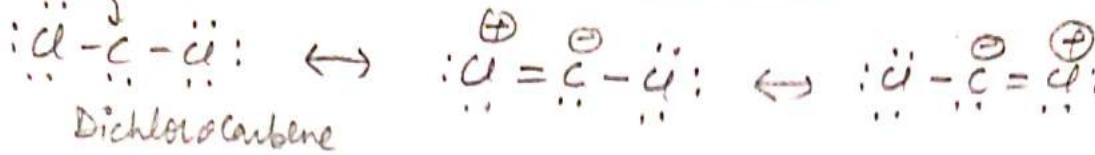
→ Singlet Carbene



Triplet Carbene

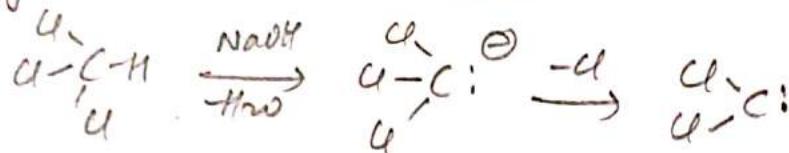


→ Stability of carbenes is due to resonance



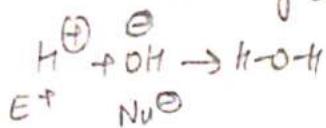
→ In general, singlet carbene > triplet carbene because e⁻ are paired in singlet, while triplet state is considered as diradicals thus are reactive entities.

→ g. Reimer-Tiemann reaction



• Reagent Types: (1). Electrophiles (2). Nucleophiles

(1). Electrophiles: → Electron-deficient species and tend to attack the substrate at a site of high e⁻ density.
(e⁻ loving)



→ They may be neutral (Lewis acids such as BF₃, AlCl₃, ZnO₂) and carbenes (:CH₂) or positively charged species.

e.g. Cl⁺, Br⁺, NO₂⁺, NO⁺, H⁺, CH₃-C=O (positively charged)
CO₂, SO₃, :CH₂, AlCl₃, BF₃ (neutral)

(2) Nucleophiles: (nucleus loving) → They are electron rich species, may be neutral having non-bonding lone pair of electrons or negatively charged.
→ Nucleophiles tend to attack the e⁻ deficient species.

e.g. Cl⁻, Br⁻, OH⁻, CN⁻, S²⁻, NH₂⁻, OCH₃ (-vely charged)
H₂O⁻, R-O-H, NH₃, R-NH₂, R₂O⁻, Me₂S⁻ (neutral)

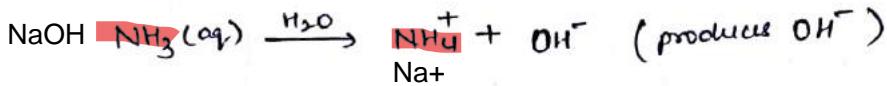
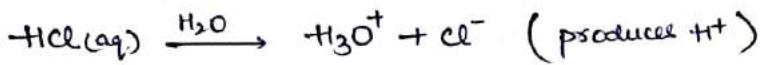
CONCEPT OF ACIDS AND BASES

(1) Aarhenius Theory : Svante Aarhenius (1857-1927)

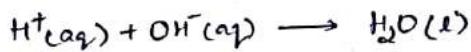
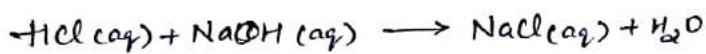
Aarhenius (1883) stated ionic compounds dissociate when dissolved in water and can become free ions acting as individual entities in solution. He defined acid & bases as.

ACID: A substance that produces H^+ in water.

BASE: A substance that produces OH^- in water.



Aarhenius acid and base neutralize each other to produce salt and water.



So, Aarhenius theory requires reactions to take place in solution (aqueous) and applies to substances only that produces H_3O^+ or OH^- .

(2) Bronsted-Lowry Theory : Johannes Bronsted (1879-1947) and Thomas Lowry (1874-1936)

In 1923, Bronsted and Lowry proposed a theory to define acids and bases. This approach was not limited to aqueous solution but for all proton (H^+) containing species. They defined acid and bases as donor and acceptor of proton respectively.

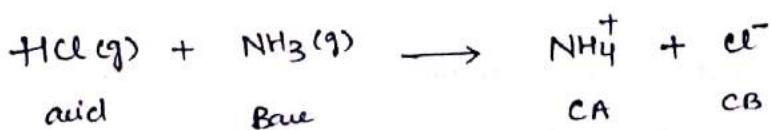
ACID: A substance that can donate proton (H^+).

BASE: A substance that can accept proton (H^+).

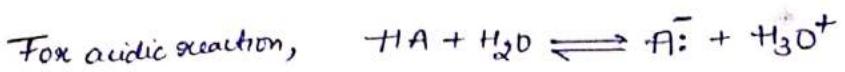
So, then proton donor (acid) must accompany a proton acceptor (base) in a chemical reaction.

→ acid transfers its proton to medium or base and reaction occurs. The product of reaction is formation of conjugate base (CB)

→ similarly, base when accepts a proton, it becomes conjugate acid (CA).



pKa and pKb values



dissociation constant, $K_a = \frac{[\text{A}^-][\text{H}_3\text{O}^+]}{[\text{HA}][\text{H}_2\text{O}]}$ in water as solvent

$$K_a = \frac{[\text{A}^-][\text{H}_3\text{O}^+]}{[\text{HA}]}$$

The negative log of K_a is expressed as $\text{p}K_a$

$$\text{p}K_a = -\log K_a$$

$$\left. \begin{array}{l} K_a \propto \text{acidic strength} \\ \text{larger } K_a, \text{ stronger acid.} \\ \\ \text{p}K_a \propto \frac{1}{\text{acidic strength}} \end{array} \right\}$$

For Base reaction,



dissociation constant, $K_b = \frac{[\text{BH}][\text{OH}^-]}{[\text{B}][\text{H}_2\text{O}]}$

$$K_b = \frac{[\text{BH}][\text{OH}^-]}{[\text{B}]}$$

likewise, $\text{p}K_b = -\log K_b$

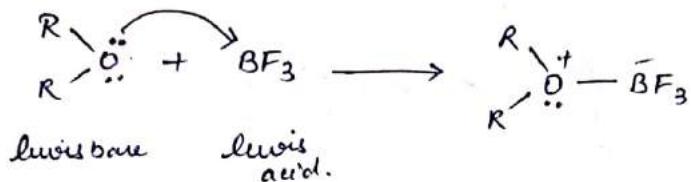
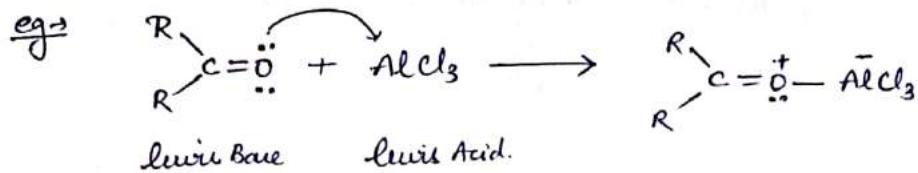
$$\left. \begin{array}{l} K_b \propto \text{basic strength} \\ \text{larger } K_b, \text{ stronger base.} \\ \\ \text{p}K_b \propto \frac{1}{\text{basic strength.}} \end{array} \right\}$$

(3) LEWIS THEORY: [Gilbert Newton Lewis (1875-1946)]

- Arrhenius theory did not support acid-base behaviour in non-aqueous systems.
- Bronsted & Lowry theory excluded non-protonated system.
- Lewis (1923), suggested theory that explained all kind of acids & bases. And theory fully developed in 1938.

ACID: electron deficient substance that can accept a pair of electrons from another substance to form a new bond.

BASE: electron rich substance that can donate a pair of electrons to other substance to form new bond.



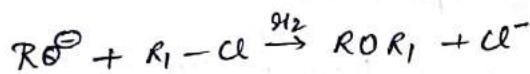
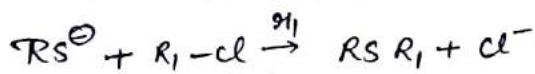
Lewis acid (eg): H^+ , BF_3 , $ZnCl_2$, $AlCl_3$, $FeCl_3$, $SnCl_4$ etc.

Lewis base (eg): H_2O^- , ROR' , $R-OH$, RCH_2O^- , R_3N , R_2S^- etc.

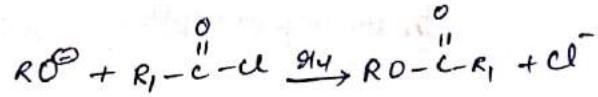
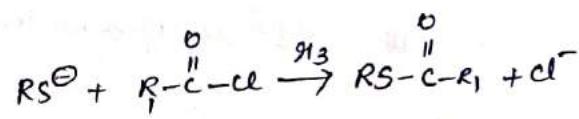
HARD AND SOFT ACIDS AND BASES:

Experimentally, it has been seen that sulfur centred nucleophile like RS^- are of high reactivity than oxygen centred nucleophiles RO^- towards alkyl halide $R-X$.

But for aryl halides, $R-C(X)R'$, reverse is true.



$$g_1 > g_2$$



$$g_4 > g_3$$

This was explained based on HSAB principle, that hard acid binds strongly with hard base & soft acid with soft base.

In organic reactions

electrophile \equiv acids

nucleophile \equiv bases.

According to Pearson's classification,

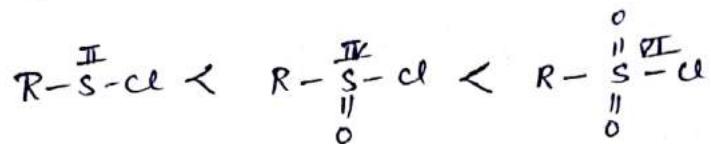
↳ hard acid (hard electrophiles) are species in which reacting atom is small and bear high positive charge & which is not easily polarisable.
so, electrophiles where central atom belongs to lower rows of periodic table are hard electrophiles.

↳ where central atom is in higher oxidation state are also strong electrophile.

4) Hardness of electrophilicity of halonium cations decreases in following order:



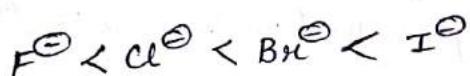
4) Electrophilicity of S atom in following species increase with increase in O-S of S atom



Softness of base or nucleophile is determined by lesser electronegativity of e⁻ such atom, higher negative charge on reacting atom & higher polarizability of e⁻ cloud around reacting atom.

e.g. RS^{\ominus} is soft nucleophile than RO^{\ominus} (because S is less electronegative than O).

4) Nucleophilicity of halide anion increases in following order:



4) RS^{\ominus} is softer nucleophile than RSH (charge density on S atom is greater in RS^{\ominus} than RSH).

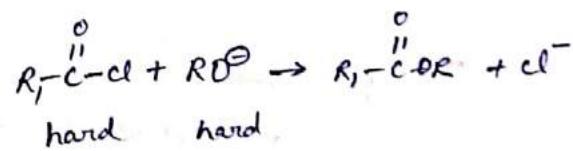
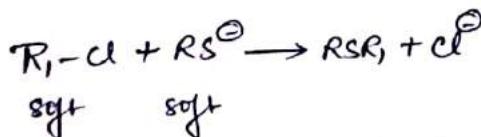
In starting example: RS^{\ominus} is soft nucleophile than RO^{\ominus}

atom of $RCOCl$ is hard electrophile than of RCl

so, $R-Cl$ is soft electrophile.

so soft acid \leftrightarrow soft base
prefer

hard acid \leftrightarrow hard base
prefer

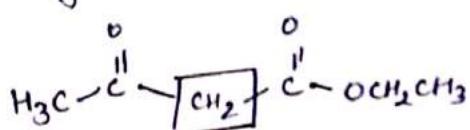


Carbon acid (Active Methylene groups)

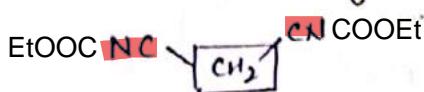
- $C_{sp^3}-H$ is not acidic due to comparable electronegativity of C atom and H-atom.
- But when strong electron-withdrawing group or groups, are attached to such C atom, the acidity of H-atom increases.
- When EWG are present on both sides, such compounds are known as active methylene or active methylene compounds
- On treatment with strong base like sodium alkoxide or lithium diisopropylamide (LDA) forms carbanions that are stabilized by π effect of EWG like $-CHO$, $-COOR$, $-CN$, $-NO_2$, $>C=O$, $-C\equiv N$.

Active methylene group compounds (example)

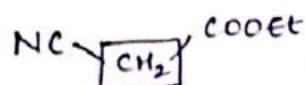
(1) Ethyl acetoacetate (EAA)



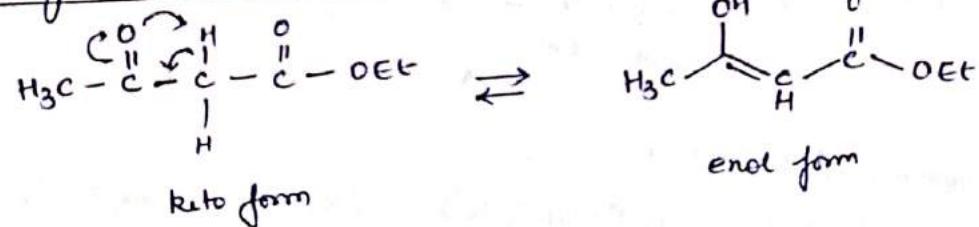
(2) Malonic ester (Diethyl malonate)



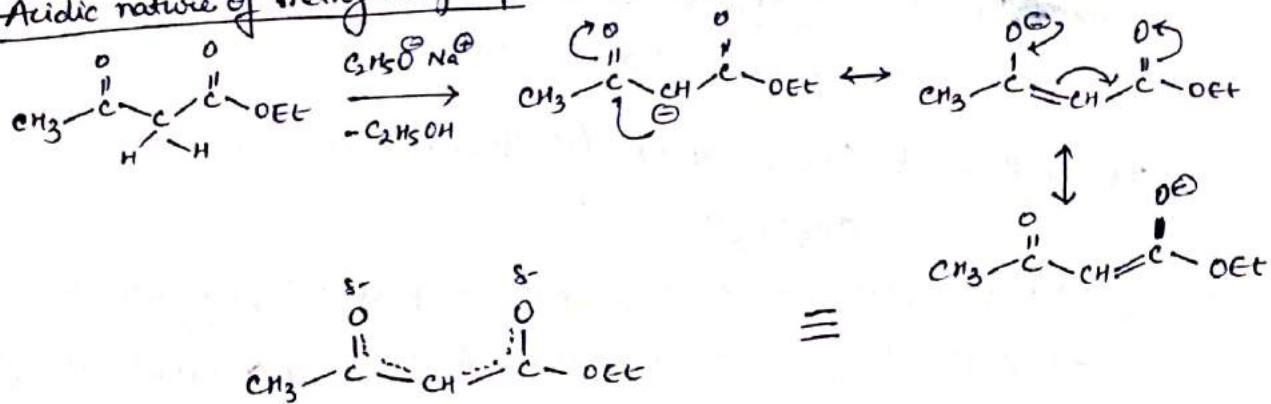
(3) Cyanoacetic ester (Ethyl cyanoacetate)



Commonly show keto-enol tautomerism:



Acidic nature of methylene group:



Super acids:

- according to classical definition, a super acid is a acid with an acidity greater than that of 100% pure sulphuric acid, which has Hammett acidity function of -12.
- according to modern definition, is a medium in which the chemical potential of the proton is higher than in pure sulfuric acid.
- more efficient proton donor than pure sulphuric acid.
- it is viscous, corrosive liquid.
- 10^{18} times more acidic than sulphuric acid.
- formed when powerful Lewis acid is dissolved in powerful Brønsted acid.

Hammett acidity function:

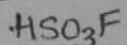
$$H_o = pK_{BH^+} + \log \frac{[B]}{[BH^+]}$$

→ measure acidity

→ proposed by Louis Pasteur Hammett.

Examples of super acid:

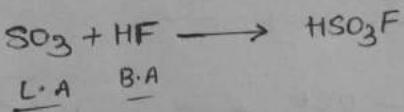
(1) Fluorosulphuric acid: ($H_o = -15.1$)



→ strongest acid commercially available.

→ tetrahedral molecule, colourless liquid (commercial samples are yellow)

→ prepared by



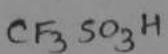
(2) Carborane ($H_o < -18$)

Chemical formula: $\text{H(C}_x\text{B}_{11}\text{Y}_5\text{Z}_6)$ ($x, y, z = \text{H, Alk, F, Cl, Br, CF}_3$)

→ estimated to be at least one million times stronger than pure sulphuric acid.

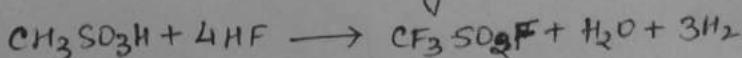
→ Strongest known Brønsted acid.

(3) Tsiflic acid ($H_o = -14.9$) (trifluoromethane sulfonic acid)



→ hygroscopic, colourless, slightly viscous & volatile in polar solvents.

→ prepared by fluorination of methane sulfonic acid (electrochemically)

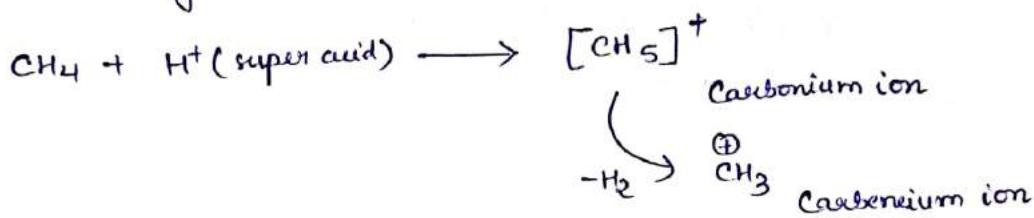


- $\text{CF}_3\text{SO}_2\text{F}$ is further hydrolyzed
 → can also be produced by oxidation of trifluoromethyl sulfonyl chloride.
 $\text{CF}_3\text{SCl} + 2\text{Cl}_2 + 3\text{H}_2\text{O} \rightarrow \text{CF}_3\text{SO}_3\text{H} + 5\text{HCl}$
 → used in research for esterification as a catalyst.

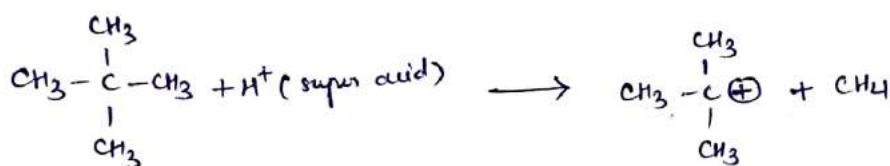
<u>Compounds</u>	<u>H₀</u>
$\text{HO}-\overset{\text{O}}{\underset{\text{O}}{\text{S}}}-\text{OH}$	-12
$\text{Cl}-\overset{\text{O}}{\underset{\text{O}}{\text{S}}}-\text{OH}$	-12.8
HClO_4	-13
$\text{F}-\overset{\text{O}}{\underset{\text{O}}{\text{S}}}-\text{OH}$	-15.1
$\text{CF}_3-\overset{\text{O}}{\underset{\text{O}}{\text{S}}}-\text{OH}$	-14.1
$\text{HO}-\overset{\text{O}}{\underset{\text{O}}{\text{S}}}-\text{C}(=\text{O})-\overset{\text{O}}{\underset{\text{O}}{\text{S}}}-\text{OH}$	-15
Magic acid $(\text{FSO}_3\text{H} + \text{SbF}_5 \rightarrow \text{HSO}_3\text{H}\cdot\text{SbF}_5)$	-23
Fluoroantimonic acid $(\text{HF} + \text{SbF}_5 \rightarrow \text{SbF}_6^- + (\text{H}-\text{FH})^+)$	-21 to -23
Carborane	-18
Trifluoroacetic acid (10^4 stronger than triflic acid)	
↪ $\text{CF}_3\text{O}_2\text{S}-\underset{\text{SO}_2\text{CF}_3}{\text{CH}}-\text{SO}_2\text{CF}_3$	

Application of super acid

① Protonation of alkane



②

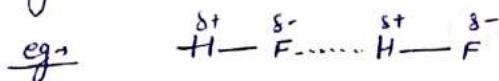


③ Stabilize carbocation due to very stable counter anion formed from super acid.

HYDROGEN BONDING

Refer Pradeep's Class XI, chapter 4, section 4.31

- A hydrogen bond is a special type of attractive interaction that exists between an electronegative atom and hydrogen atom bonded to another electronegative atom.
- Hydrogen bond is defined as electrostatic attractive force between covalently bonded H atom of one molecule and an electronegative atom of another molecule.
- H-bond is stronger than Van der Waals forces but weaker than covalent or ionic bond.

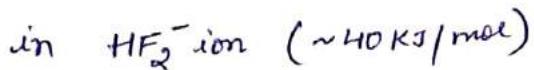
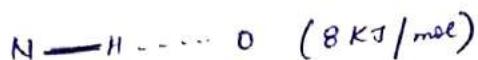
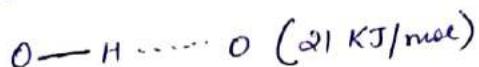
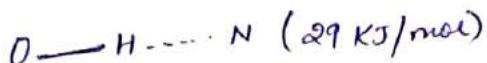


→ dipole-dipole interaction.

Conditions for H-bonding :

- ① molecule must contain a highly electronegative atom linked to hydrogen atom such as F, O or N. higher the electronegativity more is the polarization of molecule.
- ② Size of electronegative atom should be small. Smaller the size greater is electrostatic attraction.

Hydrogen bonds can vary in strength from very weak ($1-2 \text{ kJ/mol}$) to extremely strong (40 kJ/mol), as shown.

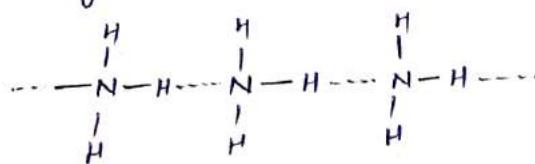


Types of H-bonding →

① Intermolecular H-bonding →

The bond between H-atom of one molecule with electronegative atom of the neighbouring molecule.

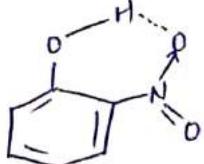
e.g. → H bonding in water, ammonia and alcohol.



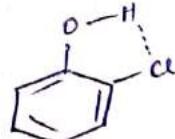
② Intramolecular H-bonding →

Bond formed within two atoms of the same molecule. This type of H-bonding is commonly known as chelation and frequently occurs in organic compounds.

e.g. (i) O-nitrophenol.



(ii) O-chlorophenol



→ Why KHF_2^- exists but KHCl_2^- does not?

→ Why glucose, proteins, nucleic etc. are soluble in water though they are covalent compound?

Effects of H-bonding -

(a) Boiling point → due to H-bonding, more energy is required to break bond, therefore increase in boiling point.

Intermolecular - H-bonding is responsible for high boiling point of water (100°C)

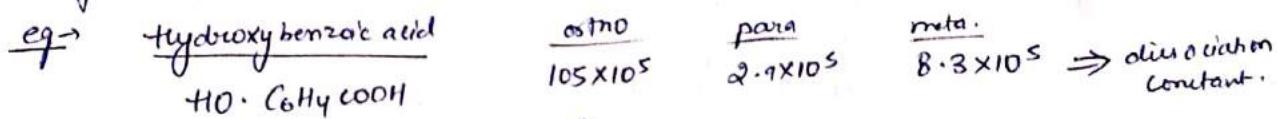
Ice have low density than water this is also due to hydrogen bonding in solid state.

(b) Solubility → substance is said to be soluble in water if it is capable of forming H-bonding with water molecule.

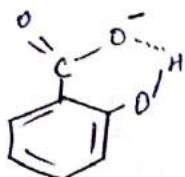
Such as alcohols are soluble in water since they form H-bond with water.

(c) Viscosity & Surface tension: compounds having H-bonding have higher viscosity & high surface tension.

(d) Strength of acid:



↑
High due
to intramolecular
H-bonding.
of its anion



→ How many H-bonds are formed by each H_2O molecule? How many water molecules are attached to each water molecule and in what direction?

= [each → 4 H bonds, each H_2O is linked to $4\text{H}_2\text{O}$ molecule, tetrahedrally]

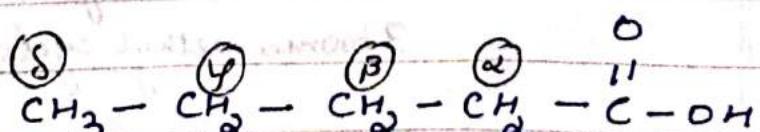
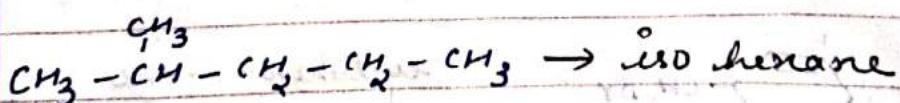
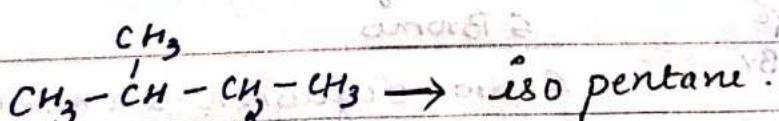
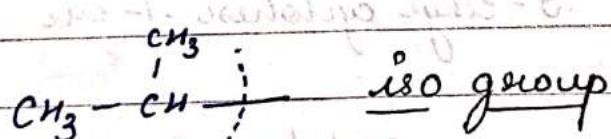
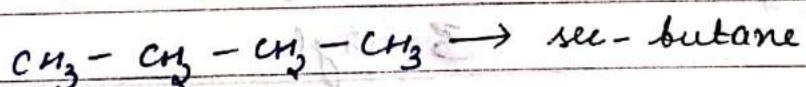
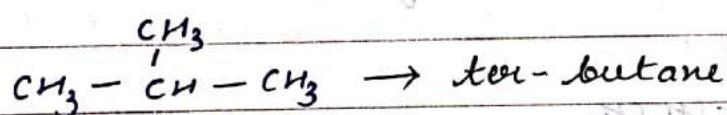
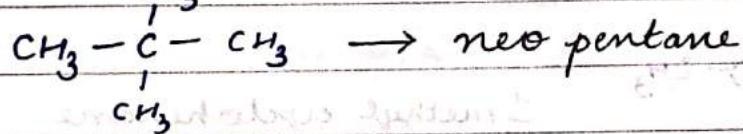
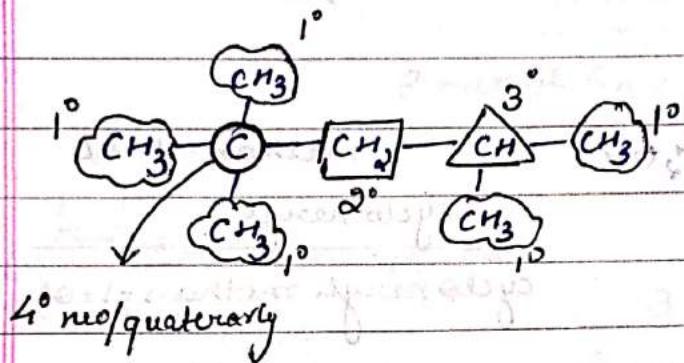
NOMENCLATURE → (INPAC)

- choose the longest possible carbon chain with MFG. (main functional group).
- ending is done by name of MFG.
- no is done from main functional group or from that side where MFG is near.
- Priority table to know the MFG.

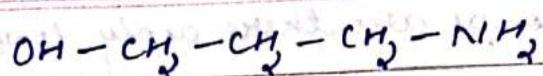
SUBSTITUENT	MFG
carboxylic	$\text{C}^{\text{O}}\text{H}$ -OH
Formyl	$\text{C}^{\text{O}}\text{H}$ -H
cyno	-CN
keto/ono	C^{O} -
hydroxyl	-OH
amino	-NH ₂
alkenyl	=
alkynyl	=
alkyl	R-H
—X—	—X—
phenyl	
nito	-NO ₂
halo	-X
alkoxy	-OR

- (1) when more groups are there apply LOWEST SUM RULE.
 (2) ALPHABETICAL ORDER (on same carbon groups).

SUBSTITUENT III	PARENT I	MFG II
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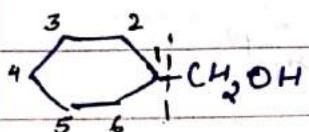
α carbon is the C which holds MFG.



propan-1-ol

3-amino

3-amino propan-1-ol



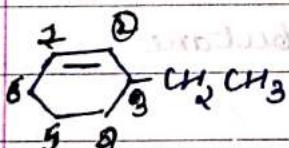
methan-1-ol

cyclo hexyl

cyclo hexyl methan-1-ol



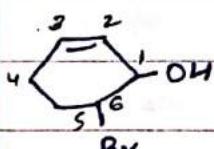
1 methyl cyclohexane.



cyclohex-1-ene

3 - ethyl

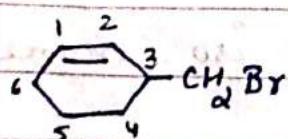
3 - ethyl cyclohex -1- ene



cyclohex-2-ene-1-ol

6 Bromo

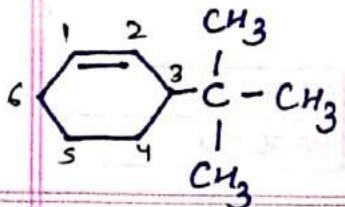
6 bromo cyclohex -2- ene -1- ol.



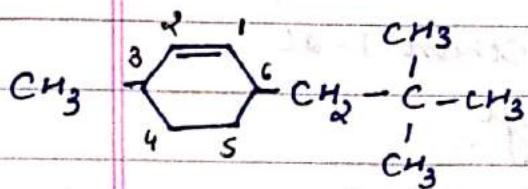
cyclohex-1-ene

3 bromo methyl

3 bromo methyl cyclohex-1-ene .

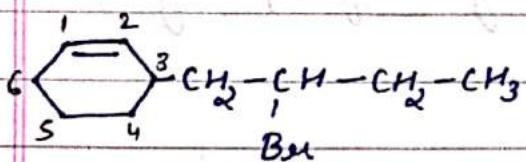


cyclohex-1-ene
3 tert butyl
3 tert. butyl cyclohex-1-ene.



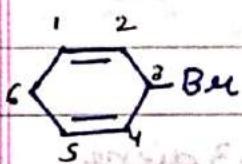
cyclohex-1-ene.
6 neopentyl
3 methyl

3 methyl 6 neopentyl cyclohex-1-ene



cyclohex-1-ene
3 butyl
2 bromo

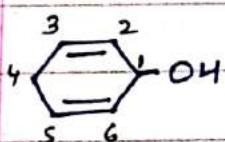
3 (2 bromo) butyl cyclohex-1-ene



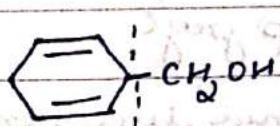
cyclohex-1,4-diene

3 bromo

3 bromocyclohex-1,4-diene.

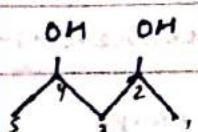


cyclohex-2,5-dien-1-ol

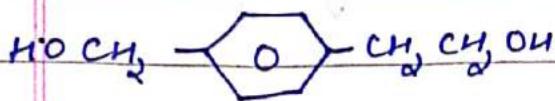


methanol
cyclohex-2,5-dienyl

cyclohex-2,5-dienyl methanol.



pentan-2,4-diol

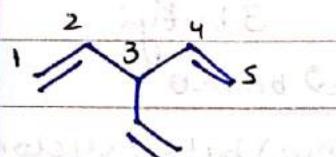


ethan - 1 - ol

2 phenyl

4 hydroxyl methyl

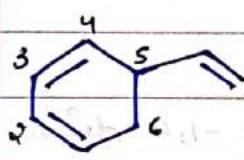
2(4 hydroxyl methyl) phenyl ethanol.



pent - 1,4 diene

3 ethenyl

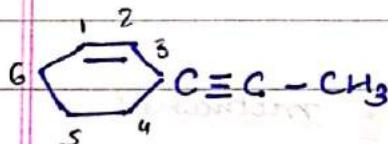
3 ethenyl pent - 1,4 - diene .



cyclohex - 1,3 diene

5 ethenyl

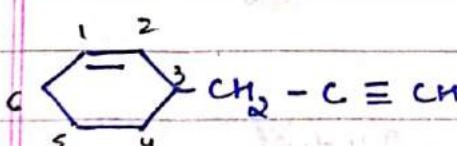
5 ethenyl cyclohex - 1,3 diene



cyclohex - 1 - ene

3 propynyl

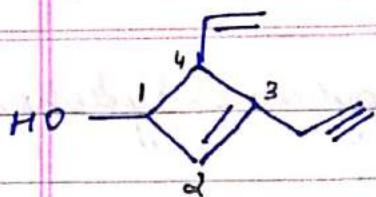
3 propynyl cyclohex - 1 - ene



cyclohex - 1 - ene

3 prop - 2 - ynyl

3 prop - 2 - ynyl cyclohex - 1 - ene

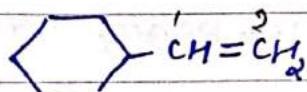


cyclobut-2-en-1-ol

4 ethenyl

3 methynyl

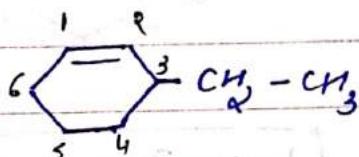
4 ethenyl 3 methynyl cyclobut-2-en-1-ol



ethene

cyclohexene

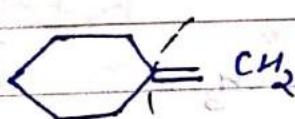
cyclohexene ethene



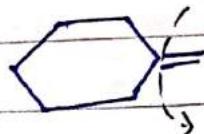
cyclohex-1-ene

3 ethyl

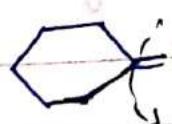
3 ethyl cyclohex-1-ene



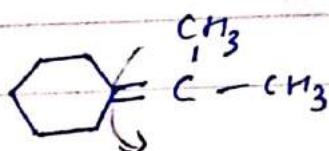
methylene - cyclohexane



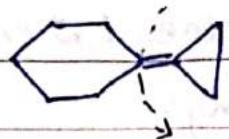
ethyldene cyclohexane



propyldene - cyclohexane



isopropylidene - cyclohexane



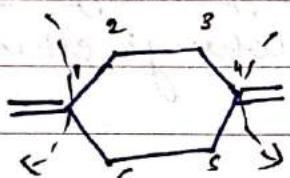
cyclopropylidene - cyclohexane



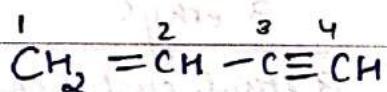
penta - 1,4 diene.

3 methylene

3 methylene penta - 1,4 diene

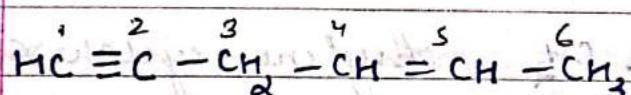


1,4 dimethylene cyclohexane



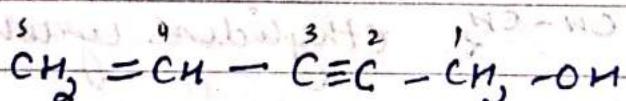
but - 3yn - 1ene X

but - 1en - 3yne



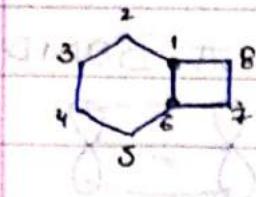
hex - 4-en - 1yne.

} lowest sum rule is done from that side where unsaturation is close.

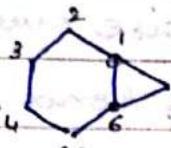


pent - 4en - 2yn - 1ol

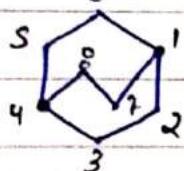
BICYCLIC COMPOUND



bicyclo[4.2.0]octane



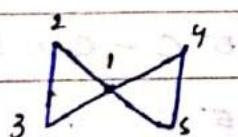
bicyclo[4.1.0]heptane



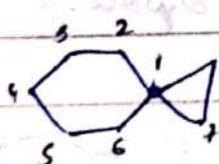
bicyclo[2.2.2]octane

CHOCYCLIC COMPOUND

SPIRAL COMPOUND



spiro[2,2]pentane



spiro[5,2]octane