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BS-109 Engineering chemistry-I

Basic concepts of Organic Chemistry

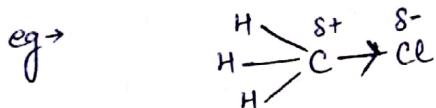
Karan Chaudhary

Organic compounds, compounds of carbon where different atoms are held together through covalent bonds. So, movement of electrons have great impact on the reactivity of that molecule. The different ways by which electronic displacements occurs in a molecule are as follow:

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

Inductive effect:

- If covalent bond is between two same atoms \rightarrow influence of atoms on bond is same.
- whereas, if bond is between two atoms of unequal electronegativity, then bonding electrons will be displaced toward the more electronegative atoms. Now bond will be polarised and have charge separation as δ^+ and δ^- .

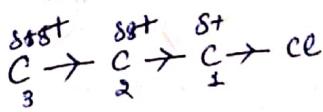


This sort of bond polarisation due to presence of electronegative element like chlorine is known as "INDUCTIVE EFFECT".

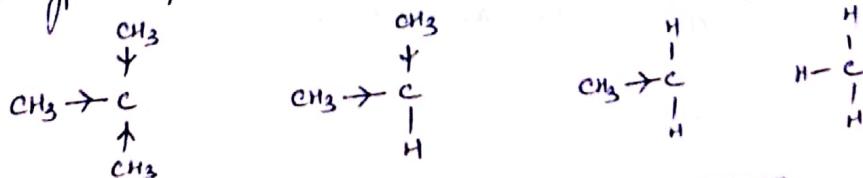
\rightarrow atoms which are more electronegative than carbon, withdraw electrons from carbon and said to exhibit -I effect. Eg \rightarrow F, Cl, Br, I, $-OH$, $-NO_2$.

\rightarrow atoms which are more electropositive than carbon, release electrons toward carbon and said to be exhibit +I effect. Eg \rightarrow Li, Na, K, alkyl.

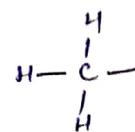
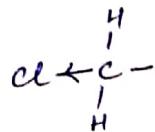
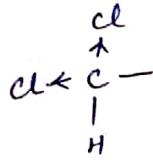
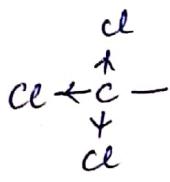
Inductive effect is seen to exist upto three carbon atoms from electronegative atom in chain, but charge on carbon atom gradually decreases, as $+S > +SS > +SSS$.



If groups showing +I or -I effect, increases on carbon atom, then inductive effect experienced is increased. Example:-



\leftarrow +I effect increases on carbon.



← -I effect increases on carbon.

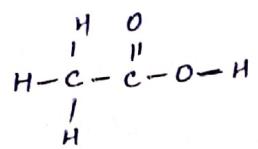
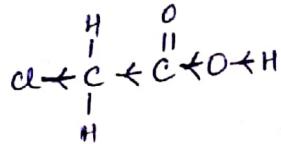
Characteristic features of inductive effect include. ?

(a) permanent effect.

(b) effect operates through σ bonds.

(c) maximum upto second carbon atom and ceases to operate beyond 4th carbon.

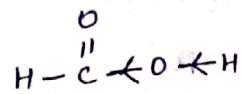
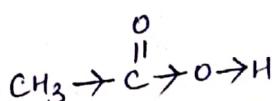
→ Chloroacetic acid is more acidic than acetic acid.



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

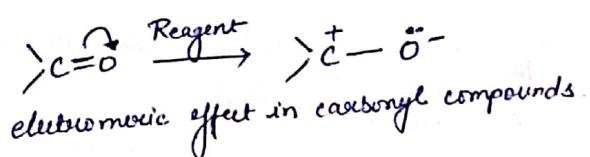
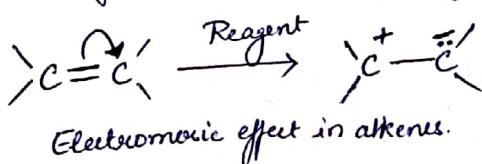
due to -I effect of Cl,
release of H from chloroacetic
acid is much easier ($K_a = 1.55 \times 10^{-3}$)

→ CH_3COOH is weaker acid than HCOOH , due to +I effect.



ELECTROMERIC EFFECT

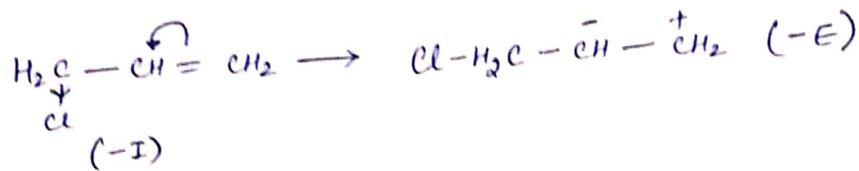
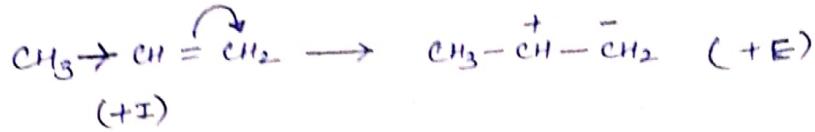
→ In multiple bonded system, shifting of π electrons towards one of the atoms under influence of attacking reagent. This effect is "Electromeric effect".



as soon as the polar reagent is removed, the transferred π electrons come back to original position & molecule behave as π bonded system.

- Electromeric effect is denoted by symbol 'E'. It has no fixed direction but occurs in direction which favours reaction.

If a group attached to multiple bonded carbon atom having +I or -I effect, it affects the direction of electromeric effect directly.

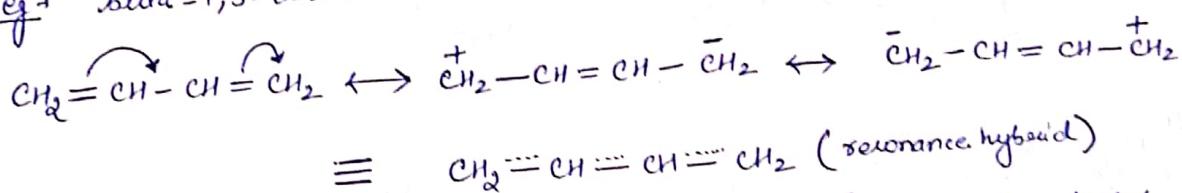


RESONANCE OR MESOMERIC EFFECT (delocalization of π electrons)

- It is a permanent effect involve delocalization of π electrons in a system.
- π electrons of double bond or π electrons of aromatic system or lone pair of e^- on atom.
- Delocalization may involve:
 - (i) $\pi-\pi$ overlap (p-orbitals are involved of π bonded system)
 - (ii) p- π overlap (atom's vacant or filled p-orbital with orbital in π bond)

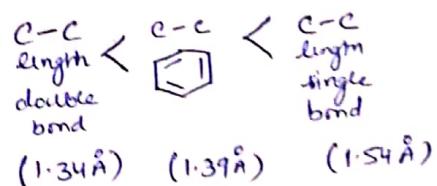
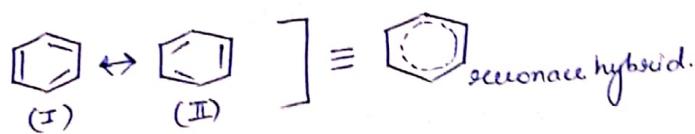
$\pi-\pi$ overlap: Here delocalization of π electrons occurs in conjugated system, where π bonds are separated by σ bonds only.

eg. Buta-1,3-diene.



C-C bond length is greater than that of double bond & smaller than that of single bond.

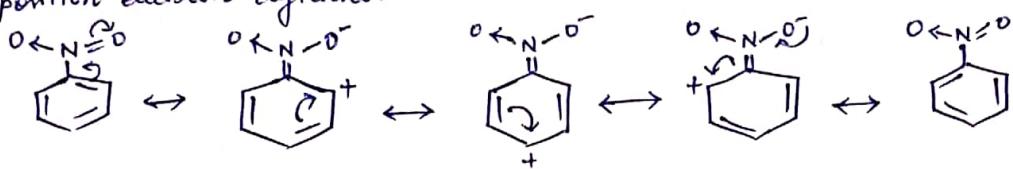
eg. Benzene, according to Kekulé, benzene have following two structures,



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

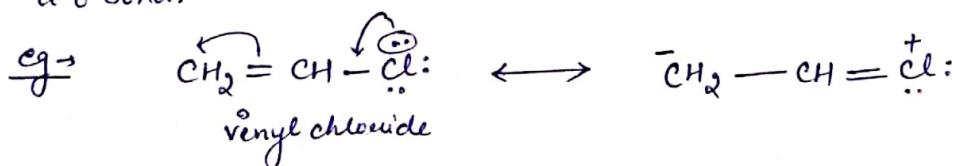
-R on -M effect

- observed when benzene attached to electron withdrawing group having π -bonds
- delocalization through $\pi-\pi$ overlap.
- meta position electron deficient.



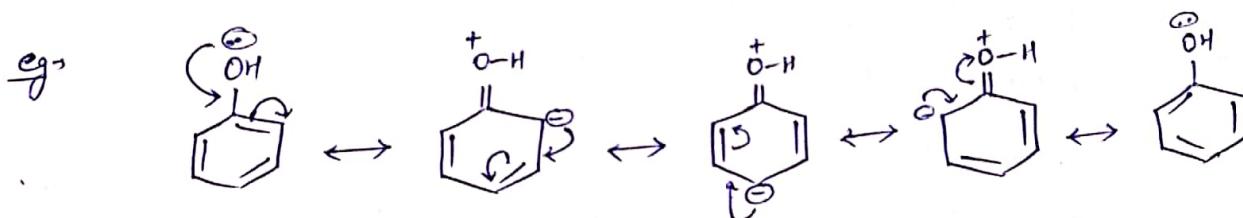
Delocalization through p- π overlap

Where p-orbital of atom (vacant, an electron or lone pair) is separated from π bond by a σ bond.



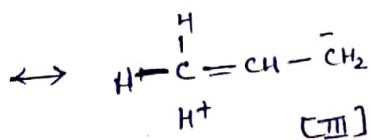
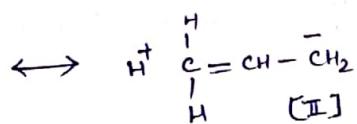
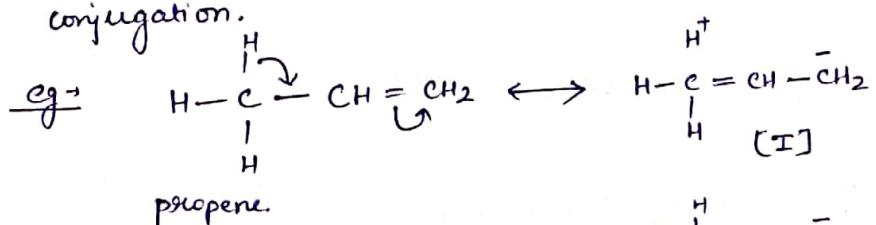
+R on +M effect

- observed when electron donating group is attached to π -conjugated system.
- makes ortho & para positions rich in electrons.



(4) Hyperconjugation

- delocalization of σ electrons through $\sigma-\pi$ or $\sigma-p$ orbitals.
- similar to resonance, but it is extended to σ bonds & therefore called hyperconjugation.

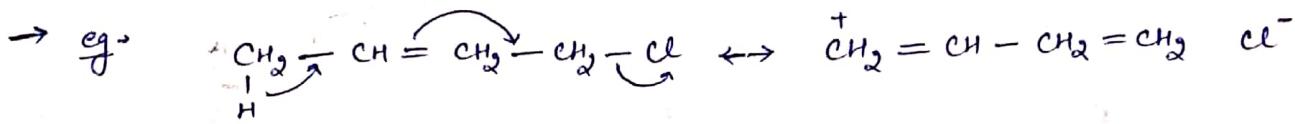


Such type is called 'Sacrificial hyperconjugation'.

b'coz no of covalent bond in structure during hyperconjugation < no of covalent bond in original structure.

In case of ethene,

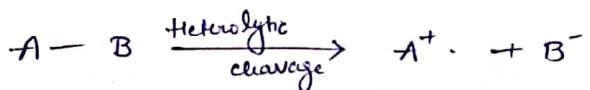
$\text{CH}_2 = \text{CH}_2$ hyperconjugation does not occur because not availability of conjugated C-H σ bonds.



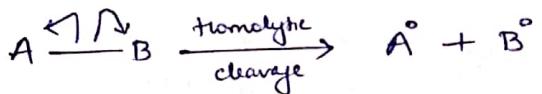
Reactive intermediates.

→ organic compounds are covalent in nature. In reaction existing bonds break and new bonds are formed. Thus bond breaks in two forms:

(1) Heterolytic cleavage: in this shared pair of electron is taken away by one atom completely (relatively more electronegative one). This result in formation of charged species, ie positively and negatively charged ions.



(2) Homolytic cleavage: during cleavage, shared pair of electrons is distributed equally between two atoms & results in formation of free radicals.



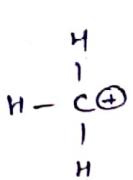
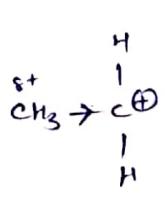
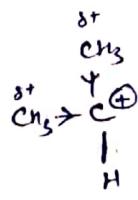
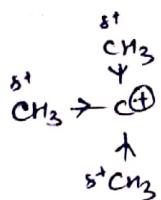
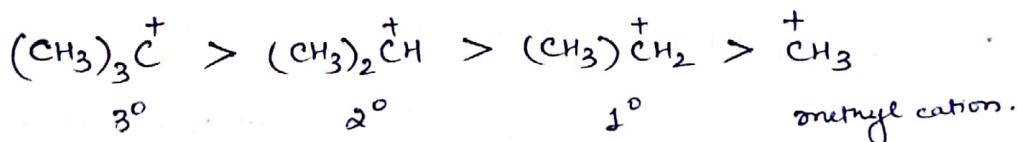
(I) CARBOCATIONS

→ carbon carries positive charge after bond breaking.

→ sp^2 hybridization, planar structure, trivalent, six electron in outer shell thus electron deficient.

→ Stability order $3^\circ > 2^\circ > 1^\circ$

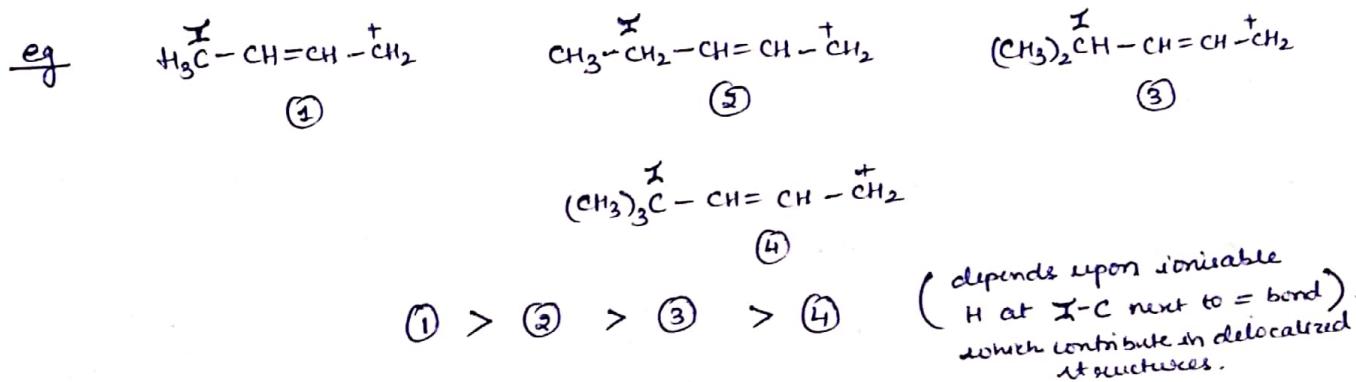
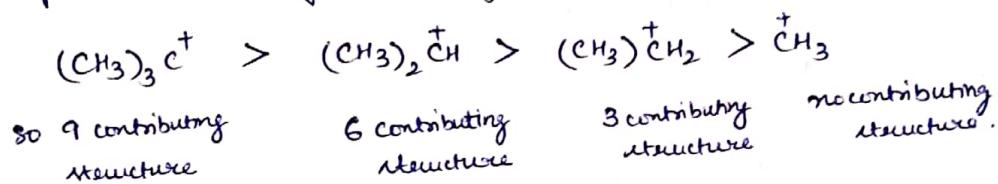
if +ve charge is neutralized, it is more stable.



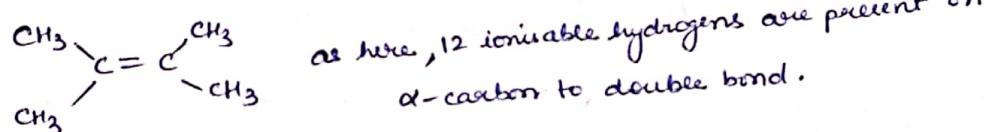
delocalization of +ve charge, due to +I effect of alkyl group. (more delocalization more stable).

Stability of carbocation due to hyperconjugation:

→ depends upon the number of ionizable hydrogen present.

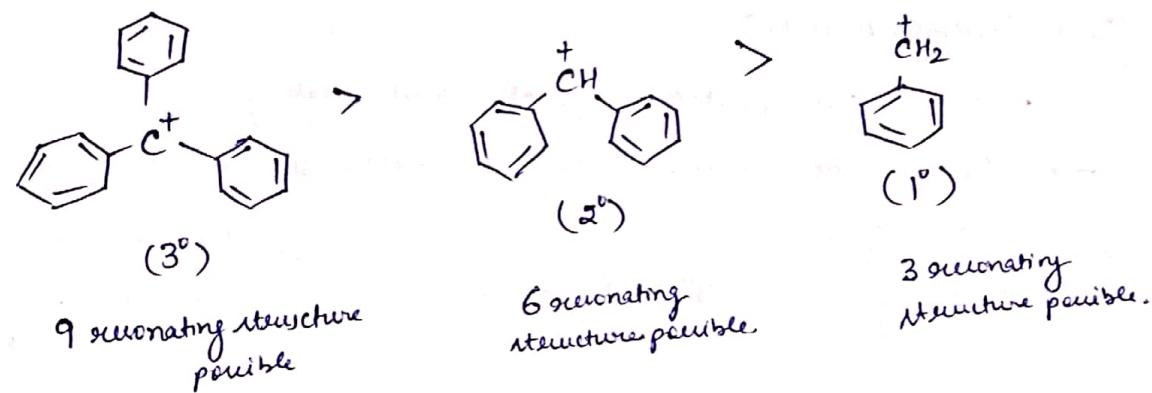


Highly substituted alkene are more stable due to hyperconjugation.

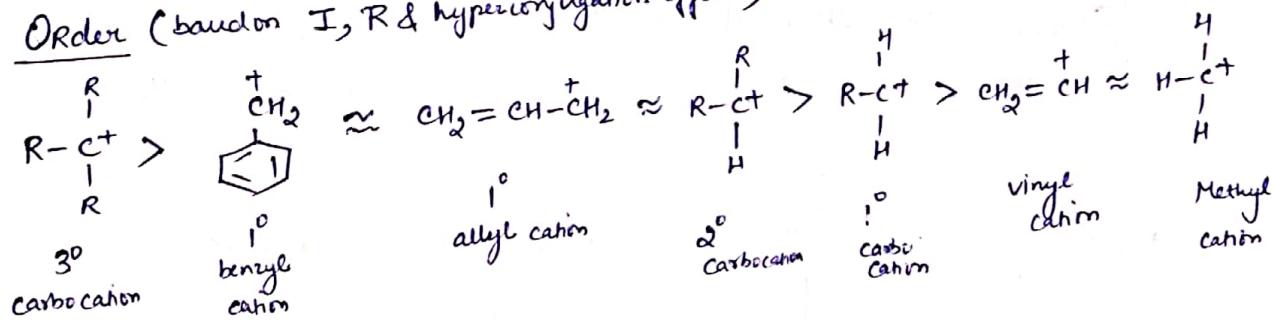


Stability of carbocations due to Resonance:

→ more resonance structure, more is the stability.



Order (based on I, R & hyperconjugation effect)



(II) CARBANIONS

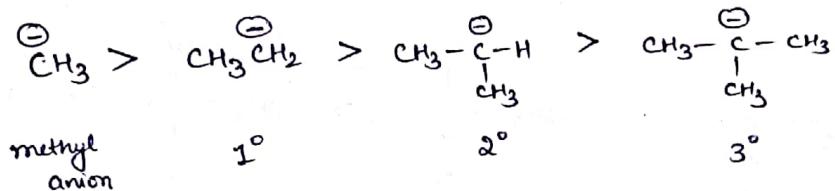
→ carbon carries shared pair of electron, have negative charge.

→ sp^3 hybridization, pyramidal geometry, tetravalent, Be^- in outer shell, electron rich.

\rightarrow Stability $1^\circ > 2^\circ > 3^\circ$



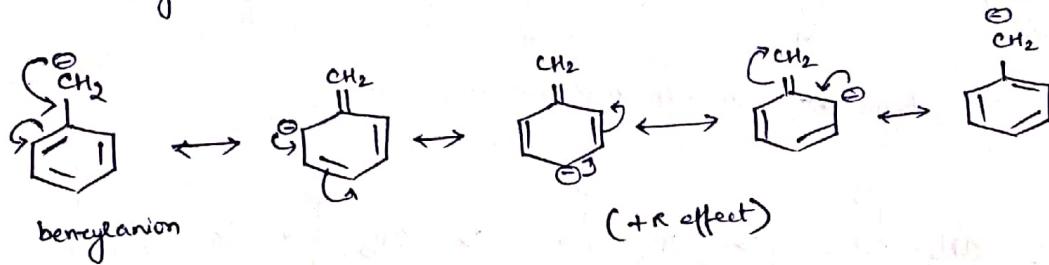
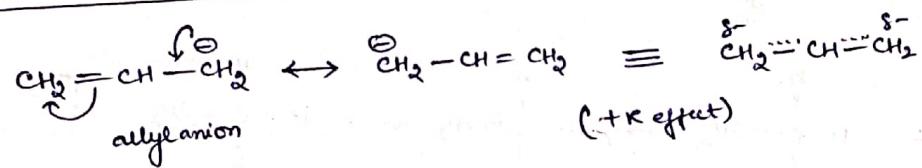
Explanation based on Inductive effect:



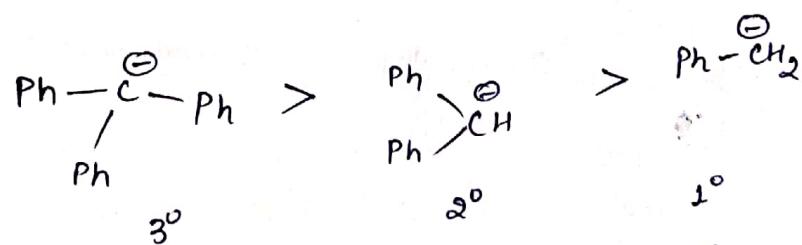
as CH_3 groups shows +I effect, as result in intensification of -ve charge on carbons and lesser is stability.

Note: e⁻ withdrawing group having -I effect, increases stability due to decrease in e⁻ density at carbon atom. as anion.

Explanation based on resonance:



benzyl anion > allyl anion [more number of contributing structures]



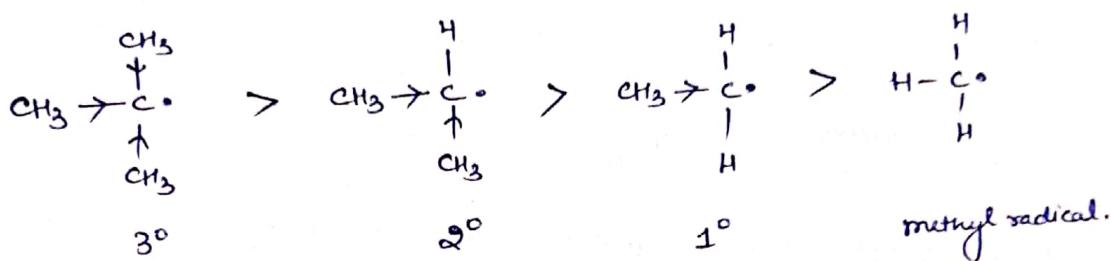
phenyl substituted methyl anion stability $3^\circ > 2^\circ > 1^\circ$

(III) FREE RADICALS :

- result from homolytic bond cleavage, carbon atom have one unpaired electron.
- sp^2 hybridized, planar structure, tetravalent, 7e⁻ in outer shell so electron deficient.
- stability order $3^\circ > 2^\circ > 1^\circ$

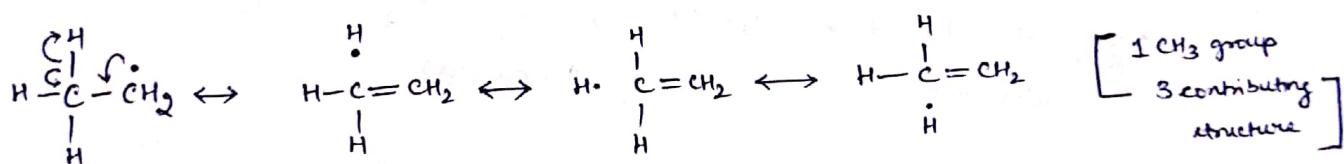


Stability based on inductive effect

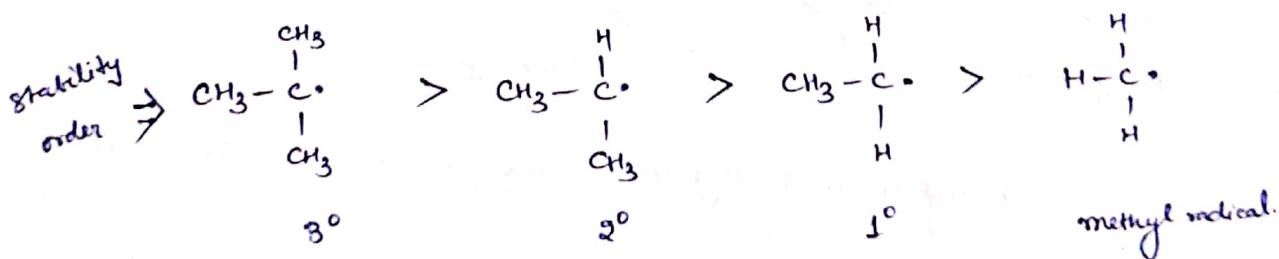


radical is e⁻ deficient, so unstable. And alkyl group releases e⁻ (+I effect), so more alkyl group attached, more availability of e⁻ & more stabilized is radical.

Stability based on hyperconjugation:



hyperconjugation in ethyl radical.



9 contributing
structure

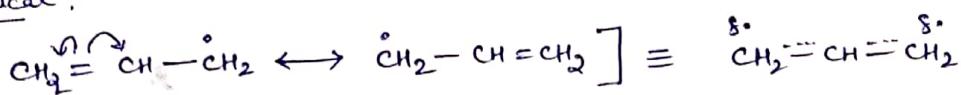
6 contributing
structure

3 Contributing
structure

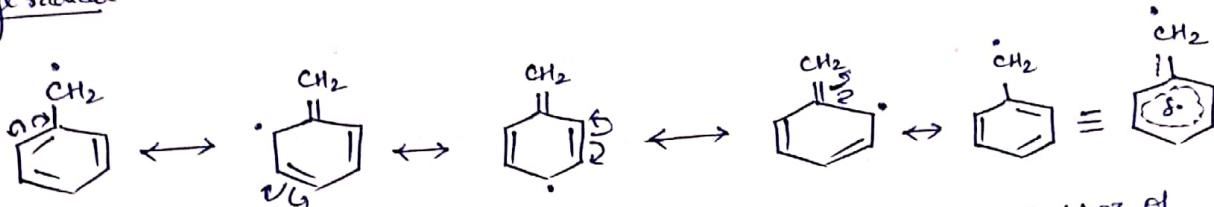
0 contributing
structure.

Stability based on resonance:

allyl radical:

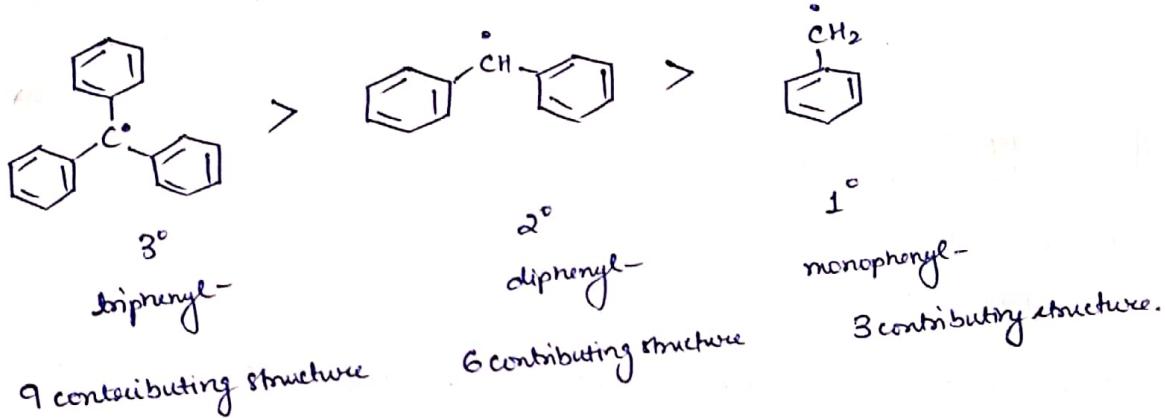


benzyl radical



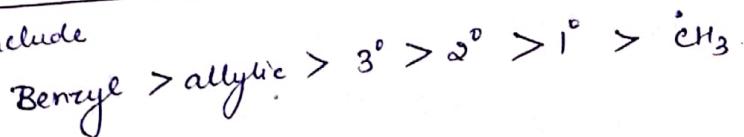
by this we can say benzyl radical is more stable than allyl radical, bcoz of more number of contributing structure.

If we compare stability of phenyl substituted methyl radicals:



Overall based on resonance

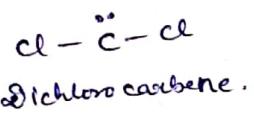
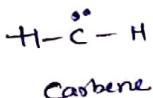
we can conclude



(IV) CARBENE

- neutral species having divalent carbon with unshared e⁻ pair
- 6e⁻ in outer shell, electron deficient, sp² or sp hybridized.

e.g.



sp² hybridized Carbene



- planar structure
- vacant p-orbital
- electron pair present in hybrid sp² orbital.
- ground state is singlet.

[2S+1]

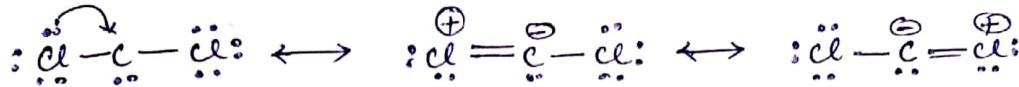
sp-hybrid Carbene.



- linear shape.
- two pure p-orbitals each carry one unpaired e⁻
- Ground state for sp carbene is Triplet.

Stability of carbene →

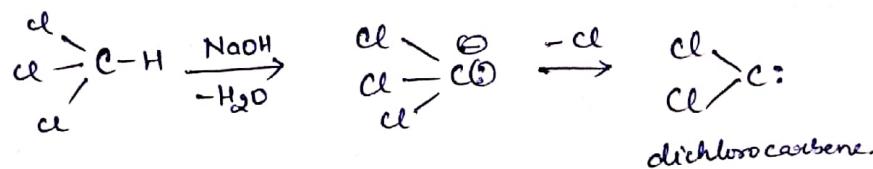
Carbene like dichlorocarbene, becomes more stable due to resonance, as shown.



In general

Singlet carbene > Triplet carbene b/c e⁻ are paired in singlet, whereas triplet state is considered as diradicals thus are reactive entities.

One of the most familiar reaction, is Reimer Tiemann reaction which involve carbene as intermediate.



~~Reagent types~~

- 1) Electrophiles.
- 2) Nucleophiles.

Electrophiles: electron deficient species so may be positive charge or neutral entity.

thus always seeking electrons. So during reactions they attack at point where is highest electron density (ie -ve charged atom).

e.g. Cl^+ , Br^+ , NO_2^+ , NO , H^+ , $\text{CH}_3\overset{+}{\text{C=O}}$ (+ve charged)

CO_2 , SO_3 , Cl_2 , AlCl_3 , BF_3 (neutral)

Nucleophiles: electron rich species, may be negatively charged or neutral molecules.

They always seek a site to which electrons can be donated during reaction.

e.g. Cl^- , Br^- , OH^- , $-\text{CN}$, $-\text{SH}$, $-\text{NH}_2$, $-\text{OCH}_3$ (-ve charged)

H_2O^- , $\text{R}-\ddot{\text{O}}\text{H}$, $\ddot{\text{N}}\text{H}_3$, RNH_2 , R_2O^- (neutral).

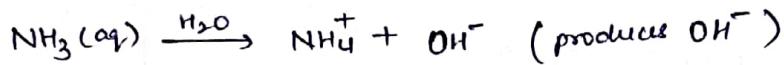
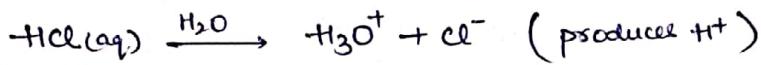
CONCEPT OF ACIDS AND BASES

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

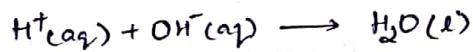
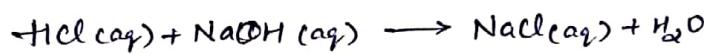
Aarhenius (1883) stated ionic compounds dissociate when dissolved in water and can become free ions acting as individual entities in solution. He defined acid & bases as.

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 acids and bases as donor and acceptor of proton respectively.

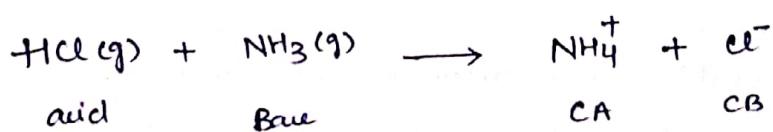
ACID: A substance that can donate proton (H^+).

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

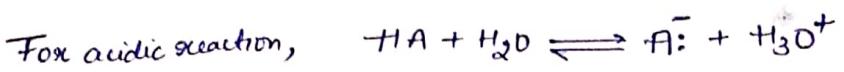
So, then proton donor (acid) must accompany a proton acceptor (base) in a chemical reaction.

→ 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

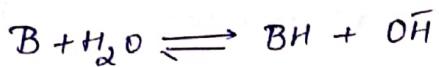
$$K_a = \frac{[\text{A}^-][\text{H}_3\text{O}^+]}{[\text{HA}]}$$

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

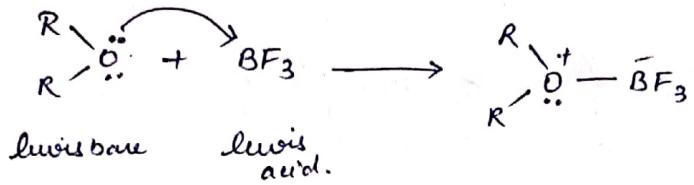
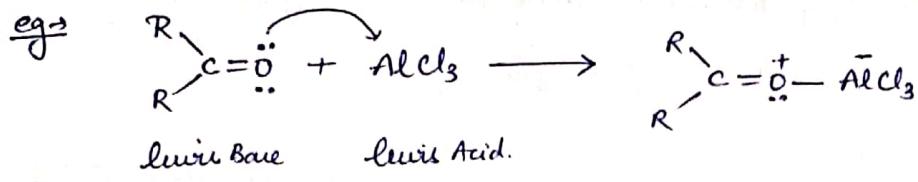
$$\left. \begin{array}{l} K_b \propto \text{basic strength} \\ \text{larger } K_b, \text{ stronger base.} \\ \\ \text{p}K_b \propto \frac{1}{\text{basic strength.}} \end{array} \right\}$$

(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.



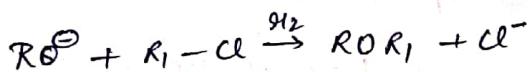
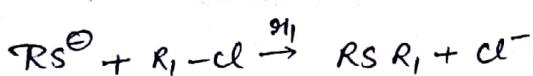
Lewis acid (eg): H^+ , BF_3 , ZnCl_2 , AlCl_3 , FeCl_3 , SnCl_4 etc.

Lewis base (eg): H_2O^- , RO^- , $\text{R}-\ddot{\text{O}}\text{H}$, $\text{RCH}=\ddot{\text{O}}$, $\text{R}_3\ddot{\text{N}}$, $\text{R}_2\ddot{\text{S}}$ etc.

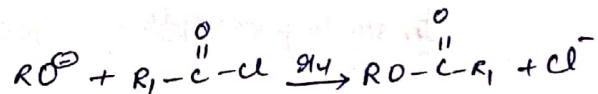
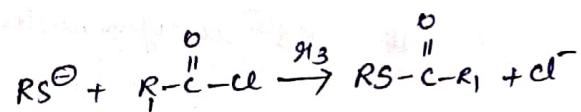
HARD AND SOFT ACIDS AND BASES:

Experimentally, it has been seen that sulfur centred nucleophile like RS^\ominus are of high reactivity than oxygen centred nucleophile RO^\ominus towards alkyl halide $\text{R}-\overset{\text{O}}{\underset{\parallel}{\text{C}}}-\text{X}$.

But for aryl halides, $\text{R}-\overset{\text{O}}{\underset{\parallel}{\text{C}}}-\text{X}$, reverse is true.



$$g_{11} > g_{12}$$



$$g_{14} > g_{13}$$

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

In organic reactions →

electrophiles \equiv acids

nucleophiles \equiv bases.

According to Pearson's classification,

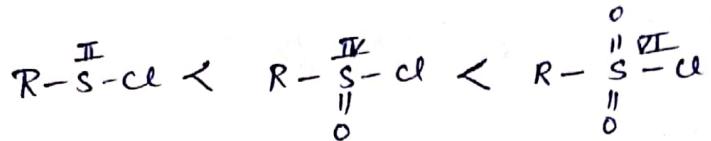
↳ hard acid (hard electrophiles) are species in which reacting atom is small and bear high positive charge & which is not easily polarisable.
so, electrophiles where central atom belongs to lower rows of periodic table are hard electrophiles.

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

Hardness of electrophilicity of halonium cations decreases in following order:



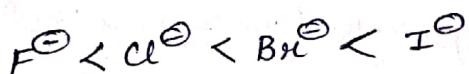
Electrophilicity of S atom in following species increase with increase in O-S of S atom



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).

Nucleophilicity of halide anion increases in following order:



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

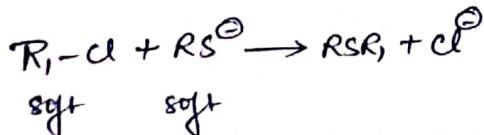
In starting example: RS^{\ominus} is soft nucleophile than RO^{\ominus}

atom of $RCOCl$ is hard electrophile than of RCl

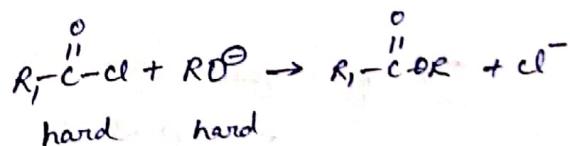
so, $R-Cl$ is soft electrophile.

so soft acid \leftrightarrow soft base

hard acid \leftrightarrow hard base



soft soft



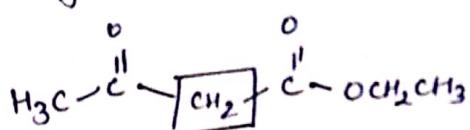
hard hard

Carbon acid (Active Methylene groups)

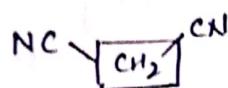
- $C_{sp^3}-H$ is not acidic due to comparable electronegativity of C atom and H-atom.
- But when strong electron-withdrawing group or groups, are attached to such C atom, the acidity of H-atom increases.
- When EWG are present on both sides, such compounds are known as active methylene or active methylene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

Active methylene group compounds (example)

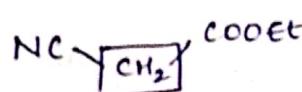
(1) Ethyl acetoacetate (EAA)



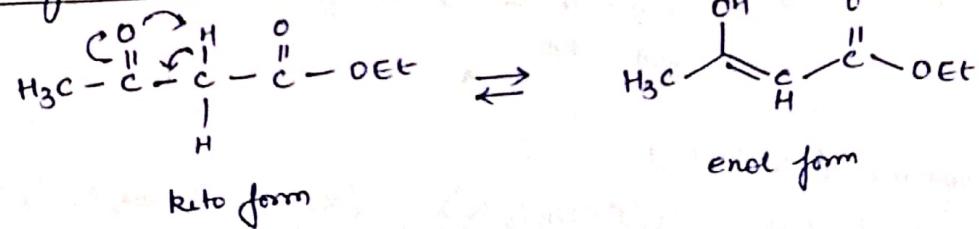
(2) Malonic ester (Diethyl malonate)



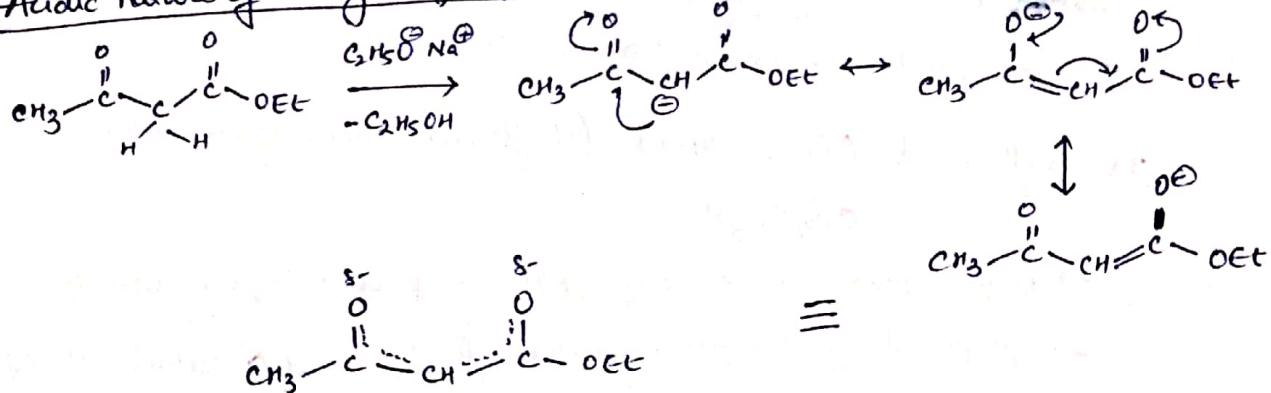
(3) Cyanoacete ester (Ethyl cyanoacetate)



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:

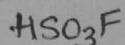
$$H_o = pK_{BH^+} + \log \frac{[B]}{[BH^+]}$$

→ measure acidity

→ proposed by Louis Pasteur Hammett.

Examples of super acid:

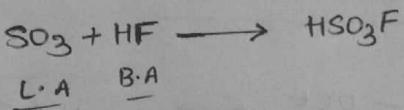
(1) Fluoro-sulphuric acid: ($H_o = -15.1$)



→ strongest acid commercially available.

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

→ prepared by



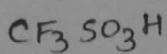
(2) Cerborane ($H_o < -18$)

Chemical formula: $\text{H(CXB}_{11}\text{Y}_5\text{Z}_6)$ ($X, Y, Z = \text{H, Alk, F, Cl, Br, CF}_3$)

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

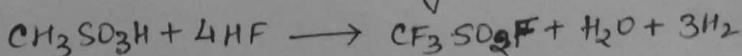
→ Strongest known Brønsted acid.

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



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

→ prepared by fluorination of methane sulfonic acid (electrochemically)

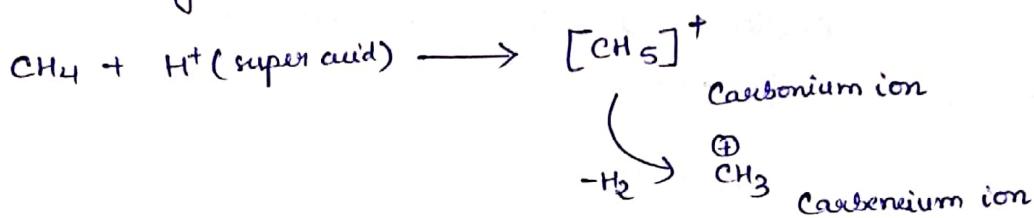


- $\text{CF}_3\text{SO}_2\text{F}$ is further hydrolyzed
 → can also be produced by oxidation of trifluoromethyl sulfonyl chloride.
- $$\text{CF}_3\text{SCl} + 2\text{Cl}_2 + 3\text{H}_2\text{O} \rightarrow \text{CF}_3\text{SO}_3\text{H} + 5\text{HCl}$$
- used in research for esterification as a catalyst.

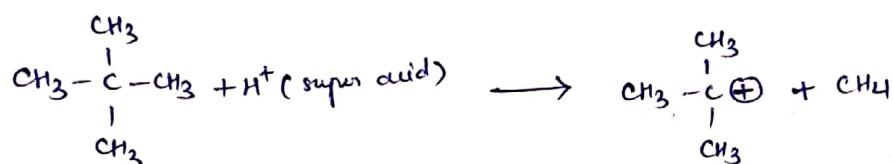
<u>Compounds</u>	<u>H₀</u>
$\text{HO}-\overset{\text{O}}{\underset{\text{O}}{\text{S}}}-\text{OH}$	-12
$\text{Cl}-\overset{\text{O}}{\underset{\text{O}}{\text{S}}}-\text{OH}$	-12.8
HClO_4	-13
$\text{F}-\overset{\text{O}}{\underset{\text{O}}{\text{S}}}-\text{OH}$	-15.1
$\text{CF}_3-\overset{\text{O}}{\underset{\text{O}}{\text{S}}}-\text{OH}$	-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)	
↳ $\text{CF}_3\text{O}_2\text{S}-\text{CH}-\text{SO}_2\text{CF}_3$ $\quad \quad \quad \quad \quad $ $\quad \quad \quad \quad \quad \text{SO}_2\text{CF}_3$	

Application of super acid

① Protonation of alkane



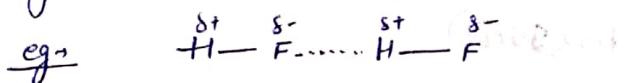
②



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

HYDROGEN BONDING

- 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.

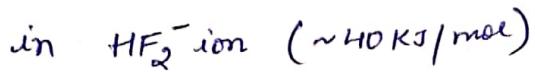


→ dipole-dipole interaction.

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.

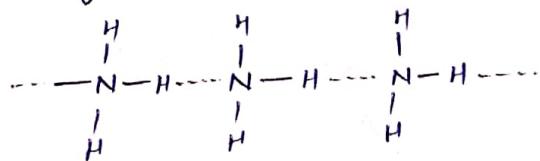


Types of H-bonding →

① Intermolecular H-bonding →

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

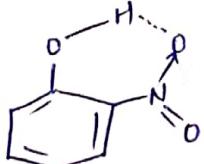
e.g. → H bonding in water, ammonia and alcohol.



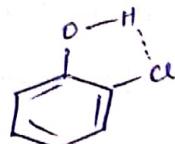
② Intramolecular H-bonding →

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



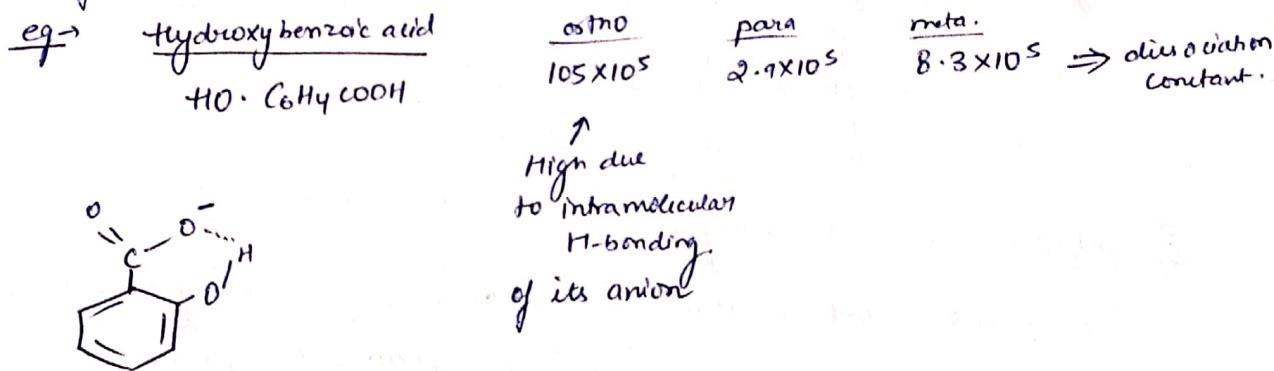
→ Why KHF_2^- exists but KHCl_2^- does not?

→ Why glucose, fructose, sucrose 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:



→ 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]

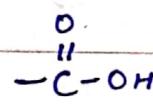
NOMENCLATURE → (INPAC)

- 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

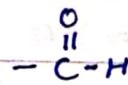
MFG

carboxylic



alkenic acid

Formyl



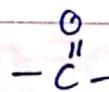
alkanal

cyno



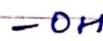
alkane-nitrile

keto/oxo



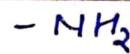
alkan-one

hydroxyl



alkan-ol

amino



alkanamine.

alkenyl

=

alkene

alkynyl

=

alkyne

alkyl



alcano

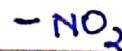
$\text{---X---X---X---X---X---X---X---}$

phenyl



Benzene

nito



halo

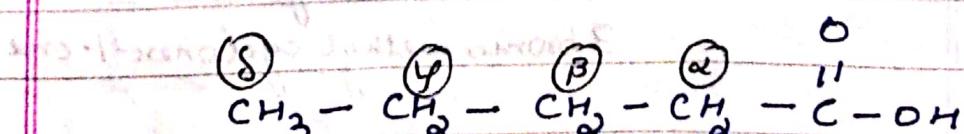
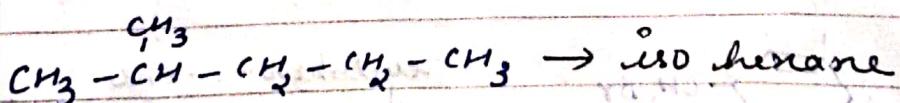
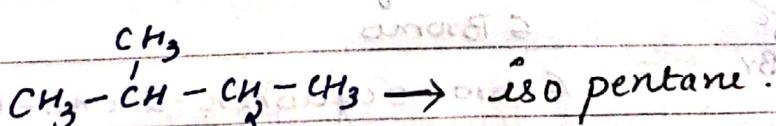
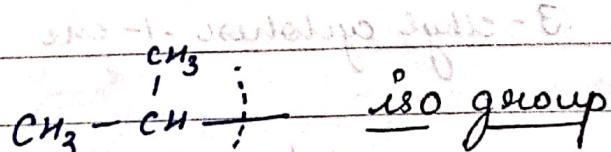
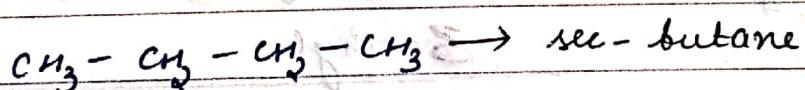
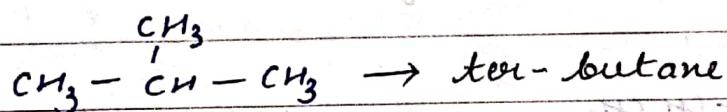
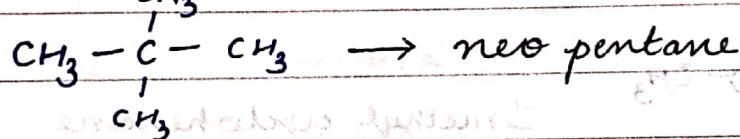
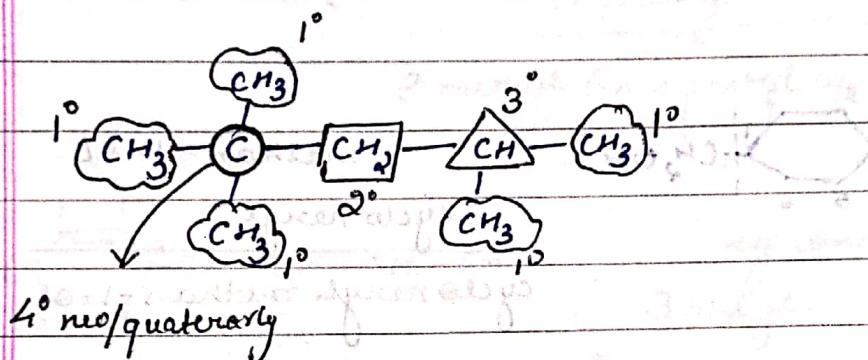


alkoxy

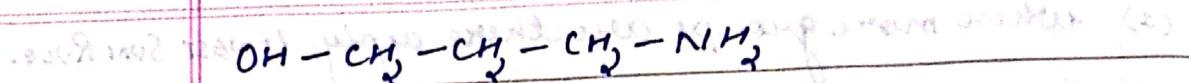


- (1) when more groups are there apply LOWEST SUM RULE.
 (2) ALPHABETICAL ORDER (on same carbon groups).

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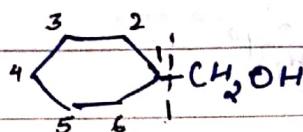
α carbon is the C which holds MFG.



propan-1-ol

3-amino

3-amino propan-1-ol



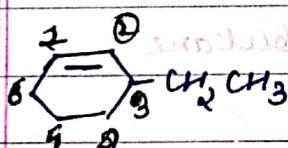
methan-1-ol

cyclo hexyl

cyclo hexyl methan-1-ol

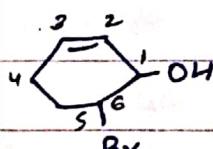


1 methyl cyclohexane.



cyclohex-1-ene

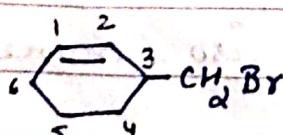
3 - ethyl cyclohex - 1 - ene



cyclohex - 2 - ene - 1 - ol

6 Bromo

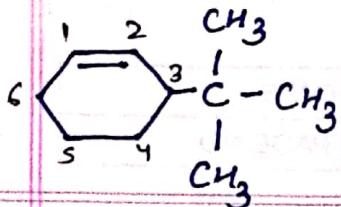
6 bromocyclohex - 2 - ene - 1 - ol.



cyclohex - 1 - ene

3 bromo methyl

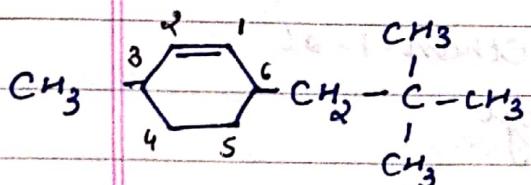
3 bromo methyl cyclohex - 1 - ene .



cyclohex-1-ene

3 tert butyl

PAGE NO.:
3 tert. butyl cyclohex-1-ene.

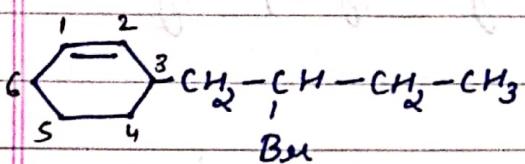


cyclohex-1-ene.

6 neopentyl

3 methyl

3 methyl 6 neopentyl cyclohex-1-ene

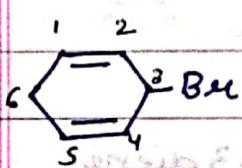


cyclohex-1-ene

3 butyl.

2 bromo

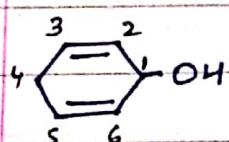
3 (2 bromo) butyl cyclohex-1-ene



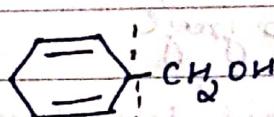
cyclohex-1,4-diene

3 bromo

3 bromocyclohex-1,4-diene.



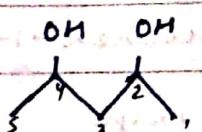
cyclohex-2,5-dien-1-ol



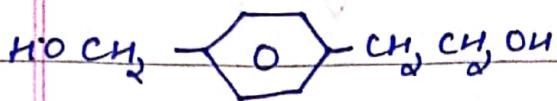
methanol

cyclohex-2,5-dienyl

cyclohex-2,5-dienyl methanol.



pentan-2,4 diol

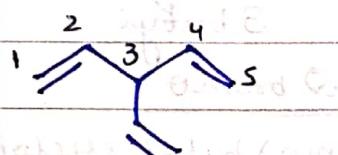


ethan - 1 - ol

α phenyl

4 hydroxyl methyl

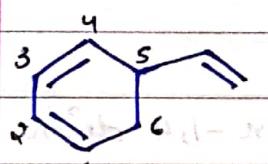
α (4 hydroxyl methyl) phenyl ethanol.



pent - 1,4 diene

3 ethenyl

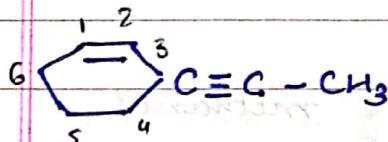
3 ethenyl pent - 1,4 - diene .



cyclohex - 1,3 diene

5 ethenyl

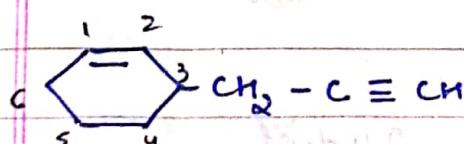
5 ethenyl cyclohex - 1,3 diene



cyclohex - 1 - ene

3 propynyl

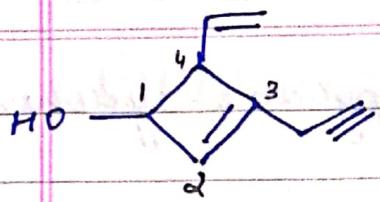
3 propynyl cyclohex - 1 - ene



cyclohex - 1 - ene

3 prop - 2 - ynyl

3 prop - 2 - ynyl cyclohex - 1 - ene

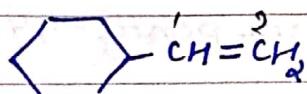


cyclobut-2-en-1-ol

4 ethenyl

3 methynyl

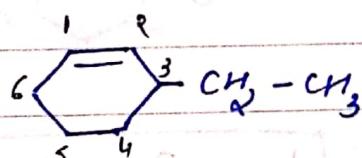
4 ethenyl 3 methynyl cyclobut-2-en-1-ol



ethene

cyclohexyl

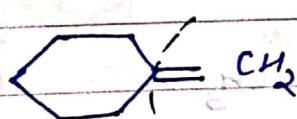
cyclohexyl ethene



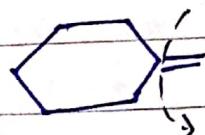
cyclohex-1-ene

3 ethyl

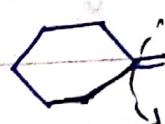
3 ethyl cyclohex-1-ene



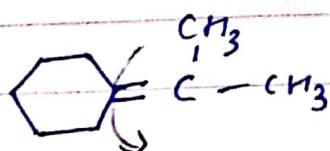
methylene - cyclohexane



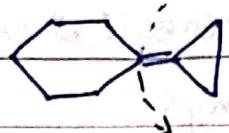
ethyldene cyclohexane



propylidene - cyclohexane



isopropylidene - cyclohexane



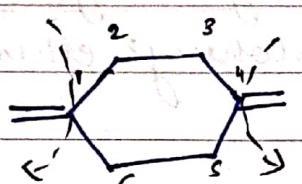
cyclopropylidene - cyclohexane



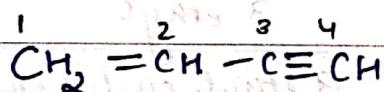
penta - 1,4 diene.

3 methylene

3 methylene penta - 1,4 diene

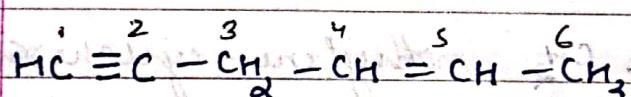


1,4 dimethylene cyclohexane



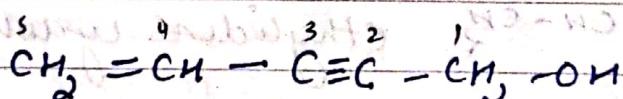
but - 3yn - 1ene X

but - 1en - 3yne



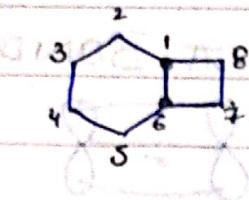
hex - 4-en - 1yne.

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

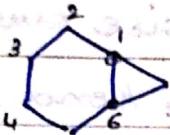


pent - 4en - 2yn - 1ol

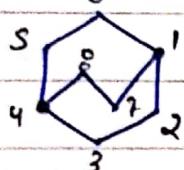
BYCYCLIC COMPOUND



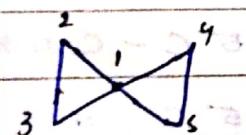
bicyclo[4.2.0]octane



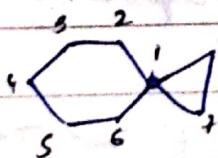
bicyclo[4.1.0]heptane



bicyclo[2.2.2]octane



spiro[2.2]pentane



spiro[5.2]octane