

## Chapter –I Structure and Bonding

**Importance of Organic Chemistry:** Organic Chemistry is defined as the study of carbon compounds. Organic Chemistry is a separate discipline due to rapid increasing compounds each year (Approx.5 million) and several thousand new compounds are synthesized each year. In case of Inorganic Chemistry there are approximately 10,000 known Inorganic compounds. Secondly the unique physical and chemical property shown by organic compounds which make organic chemistry separate branch more practical and useful. Third is unique character of atom that is catenation property of carbon atom which is responsible for the variety and large number of organic compounds. Thus no field of science is as closely related with our daily activities as is organic chemistry. The food we eat is mainly organic in nature. The changes which this food undergoes in our bodies are organic chemical reactions metabolism, growth and maintain of our bodily functions involves organic chemistry. The cloth we wear, the dyes that color them, the soaps and starch used to launder them, the leather in our shoes, as well as the dye and shoe polish are products of organic industry.

Many of the appointments in our motor cars, their fuels and lubricants and the fuel which power our industrial plants are all organic in nature. The tremendous importance of organic compounds in everyday life is given as,

**Food:** proteins, fats, carbohydrates etc.

**Clothing:** cotton, silk, wool, nylon, rayon, Dacron etc.

**Shelter:** wood, paints, varnishes etc.

**Power and transportation:** natural gas, petroleum products, coal etc.

**Medicines and drugs:** penicillin G, streptomycin, LSD etc.

**Insecticides:** Treflan, 2,4-D etc.

Hormones and steroids, vitamins and enzymes, antiseptics and anesthetics, pigments and

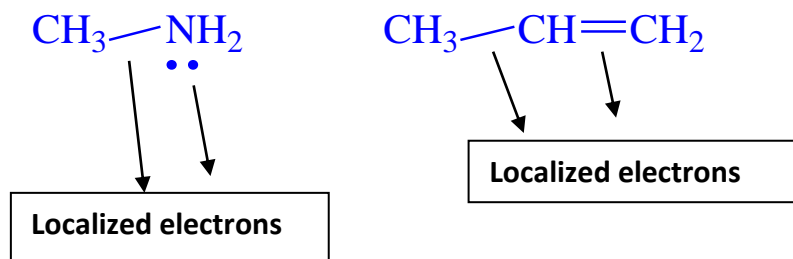
dyes, paper and inks, photographic film and developers, perfumes and flavors, plastics, rubber and resins, explosives, soaps and detergents etc.

The course of civilization has been greatly affected by the advances in medicine; much of the advance has been due to the introduction of such organic compounds as antiseptics, anesthetics and antibiotics. Disease has been checked, the death rate reduced and the life expectancy of mankind doubled within the last half century.

**Introduction of Structure and bonding:** At the heart of Organic Chemistry are fundamental concepts of molecular structure and reactivity of carbon containing compounds. The properties and reactions of organic compounds can be understood on the basis of their structure. Structural theory plays an essentially central role in the study of organic molecules. Chemists can use the theory of structure and bonding to explain the physical and chemical properties of materials of widely varying composition e.g. salt crystals, metals and polymer plastics and many more organic molecules...

Chemical bonding theory (covalent, ionic and metallic) explains how atoms are held together in these different types of structure. The bonding and structure of substances determine their properties. There are various elements which hold the greatest interest in bonding with carbon to form various useful organic compounds.

**Localized Chemical Bonding:** Localized chemical bonding may be defined as bonding in which the electrons are shared by two and only two nuclei. In this type of bonding electrons that are restricted to a particular region. Localized electrons are not in resonance. For example, covalent bond between two hydrogen atoms of  $H_2$  molecule. There is greatest possibility of finding electrons in the region between the two nuclei. Concentration of negatively charged electrons between the two positive nuclei that holds the nuclei together. Since spins of the two electrons is antiparallel, this produces less repulsion between two electrons, tending to concentrate them in the internuclear region. The net result is that the electron density for paired electrons is greatest between the two nuclei. Due to localization of electron pair in a chemical bond gives rise to the properties of bond lengths, dipole moment, force constants etc.



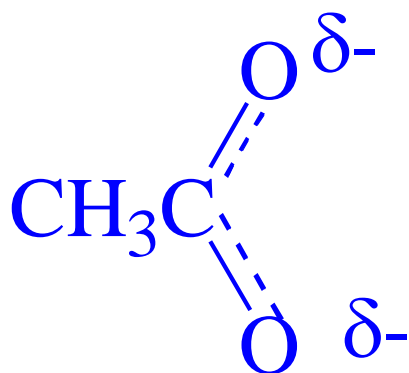
**Delocalized chemical bond:** A bond pair that moves between two different pairs of atoms is considered delocalized. You can identify delocalized bonds by checking the electron locations in two different resonance forms; if the pair changes location and form, it is delocalized. Delocalization happens when electric charge is spread over more than one atom. The term delocalization is general and can have slightly different meanings in different fields. In organic chemistry, this refers to resonance in conjugated systems and aromatic compounds.

In the delocalized chemical bonding the electrons neither belongs to a single atom nor are confined to a bond between two atoms, but are shared by three or more atoms.

It is process of bond formation involving delocalizes electrons. Delocalization is characteristics of pi electrons, where the pi electrons change its position in between different sub orbital. (Changes location).

#### Why delocalization occurs?

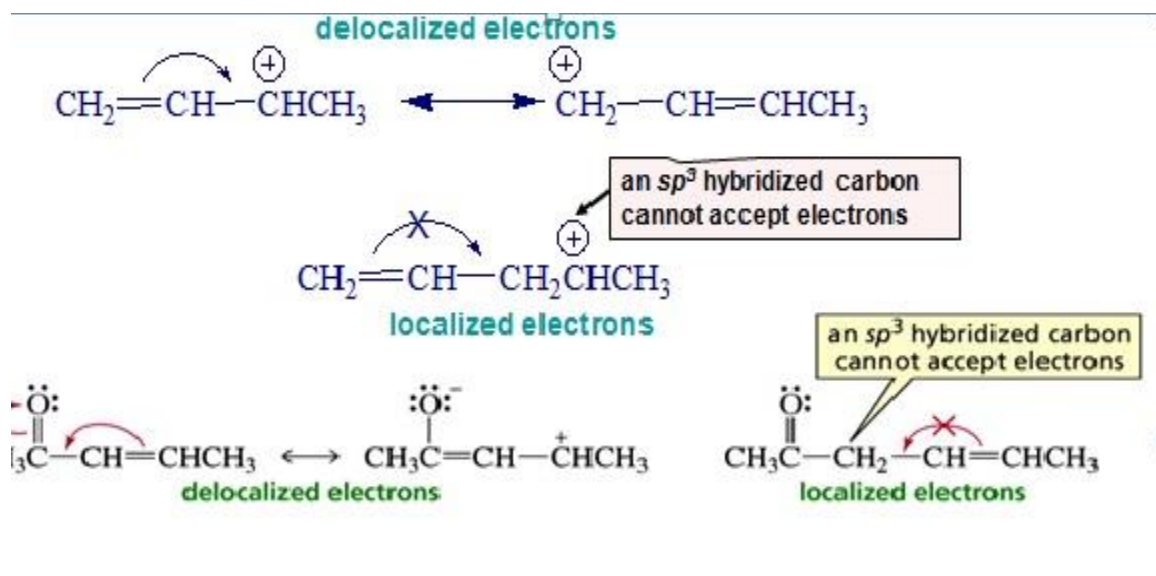
- 1) Delocalization is characteristics of pi bond.
- 2) It occurs due to presence of odd double and triple bond which is characteristics of hybridization.
- 3) Delocalization involves  $sp^2$ ,  $sp^3$  and other complex hybridization.
- 4) Delocalization is carried out by forming delocalized bond to maintain the stability of the molecule.
- 5) Delocalized bonding (resonance) exists for molecules that differ only in the allocation of single and double bonds to the same kind of atoms.



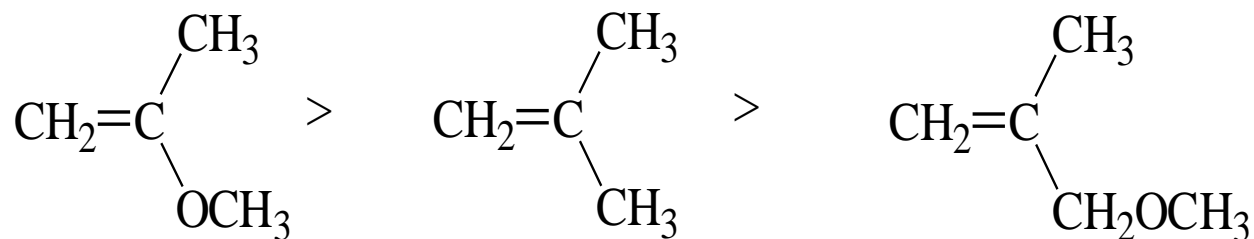
The Difference between Delocalized and Localized Electrons



an  $sp^3$  hybridized carbon cannot accept electrons

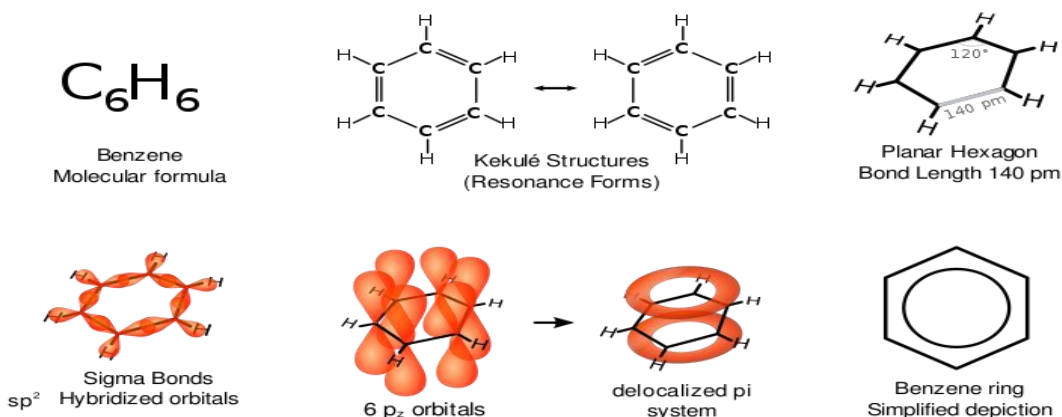


Delocalized electrons can affect the reactivity of a compound for example Relative reactivity toward HBr..

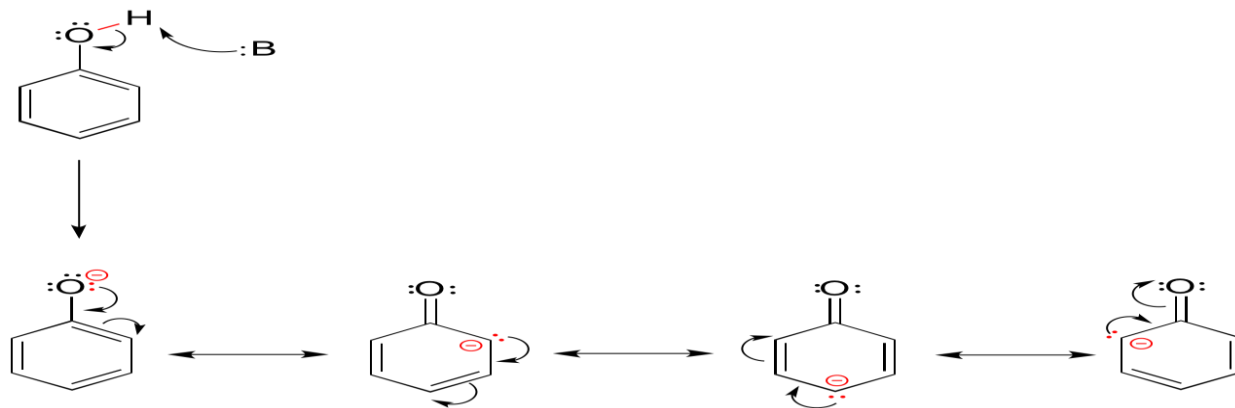


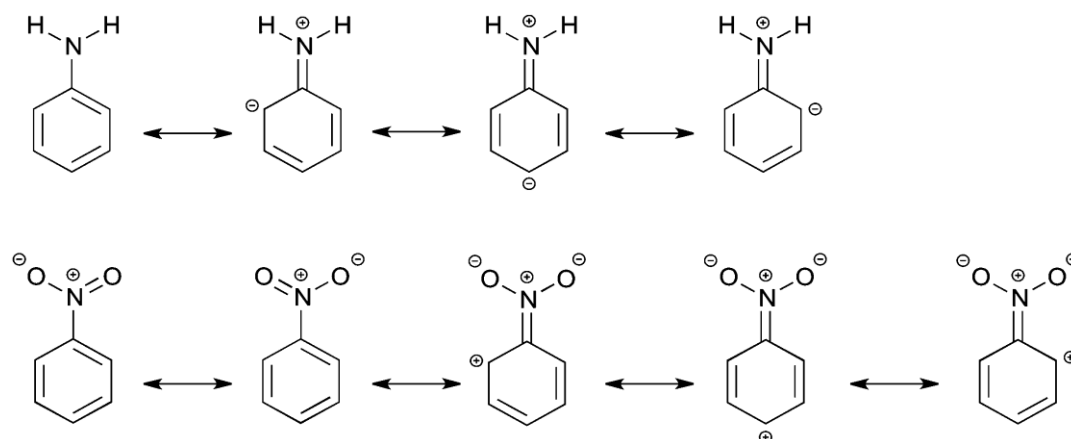
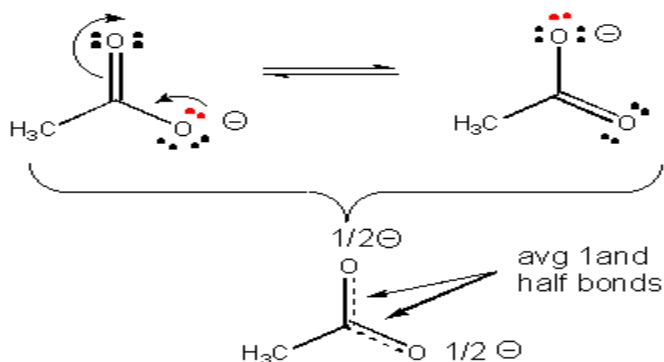
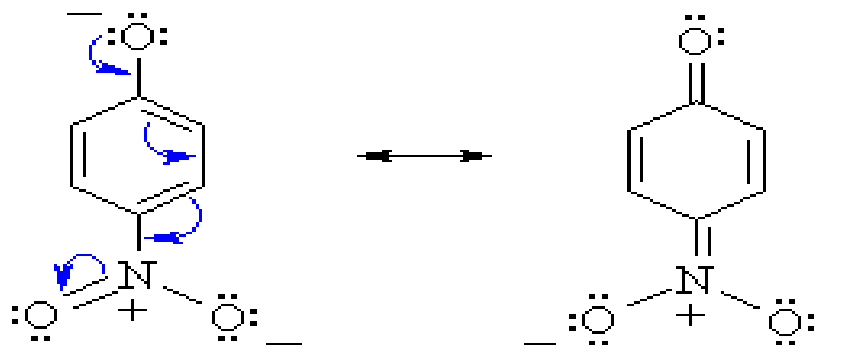
Other examples are,

**1) Benzene:** Benzene, a common organic solvent, is the simplest example of an aromatic compound. ... Benzene is also a cyclic molecule in which all of the ring atoms are  $sp^2$ -hybridized that allows the  $\pi$  electrons to be delocalized in molecular orbital that extend all the way around the ring, above and below the plane of the ring.



**2) In Phenol:**



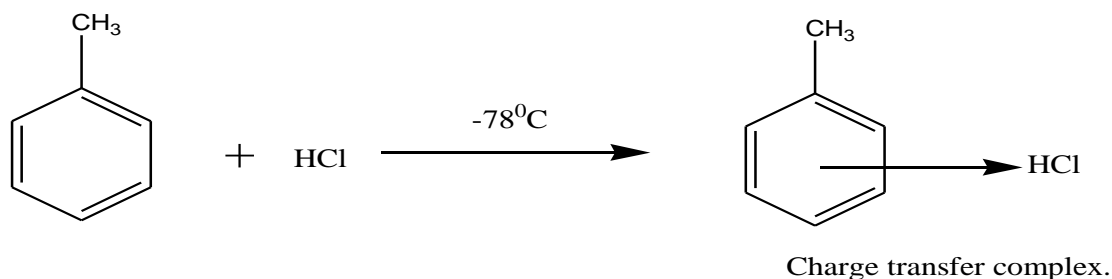
**3) In Amines and Nitro compounds:****4) In acetic acid:****5) In para nitro phenol:**

Resonance delocalisation of the negative charge from the phenolate to the oxygen of the p-nitro group. p-Nitrophenol has a similar acidity to the o-isomer.

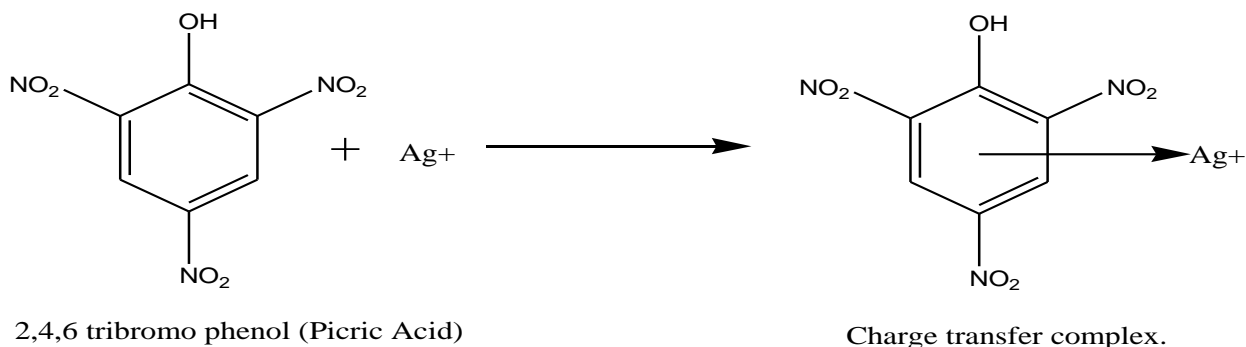
**Charge transfer complexes (CT complex) or electron-donor-acceptor complex:**

When two or more reactant **combines** with each other results in single product generally called as addition reaction and **product contains all the mass** of two or more reactants, such product is also called as addition compound.

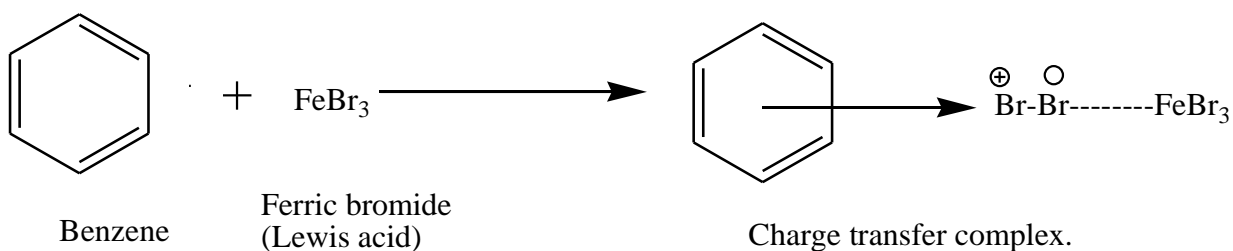
- 1) In this type of complexes, one molecule acts as **donor (D)** and thus **donates an unshared pair** of electrons or has pair of electrons in second orbit of double bond or aromatic system.
- 2) Another molecule capable of accepting electron acts as **acceptor (A)**.  
When the two molecules combine due to attractive forces, a bond results between donor and acceptor molecule such an interaction is called as electron doner-accepter or Charge transfer interaction and formed complex is known as electron donor-accepter (**EDA**) or Charge transfer (CT) complex.
- 3) **Speed of EDA formation:** The formation of EDA complexes facilitated (fast formation) by presence of electron withdrawing group(s) present on acceptor molecule and electron withdrawing group on donor molecule.
- 4) The distance between donor and acceptor **is about 3-3.5 Å<sup>0</sup>**, which is **larger** than the normal **covalent bond** length.
- 5) CTC shows **dipole moment** which indicates the charge separation in ground state of EDA complex.
- 6) Examples are, A) toluene forms CTC with HCl at  $-78^{\circ}\text{C}$ . Here pi electrons of pi electron cloud (acts as donor) are responsible for formation of complex.



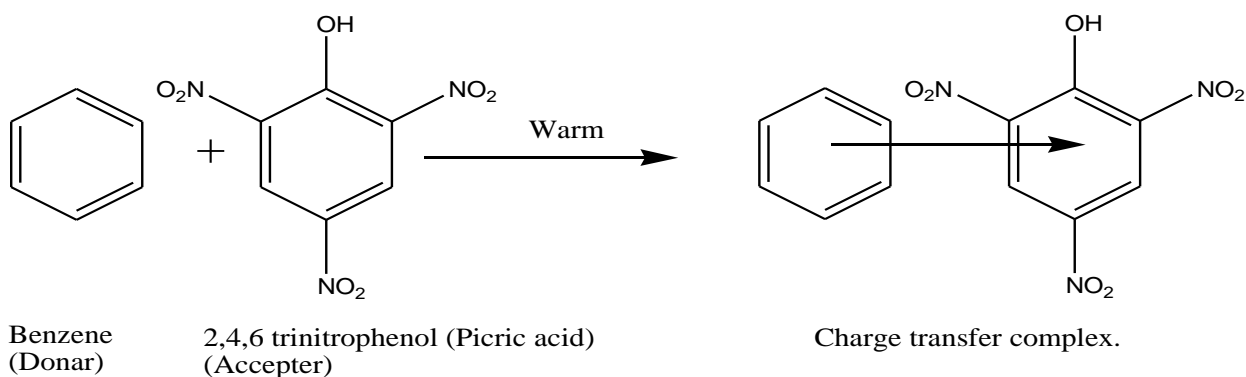
B) Aromatic hydrocarbons also forms CTC complex with halogens and silver cations. for example 2,4,6 trinitro phenol (Picric acid) forms CTC with silver cations.



C) Benzene in the presence of Lewis acid like FeBr<sub>3</sub> reacts with Br<sub>2</sub> to form bromobenzene. Mechanism shows there is formation of EDA complex.

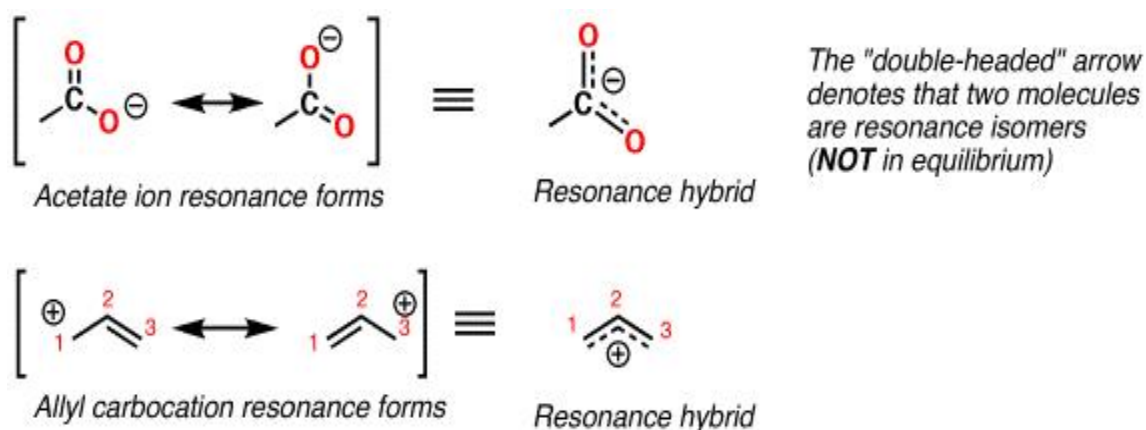


D) Picric acid (A) forms stable colored crystalline CTC complex called as picrates, generally with aromatic hydrocarbons (D) like Naphthalene and Anthracene. Bonding is possible because as donor and acceptor molecules lie in same plane/parallel plane.

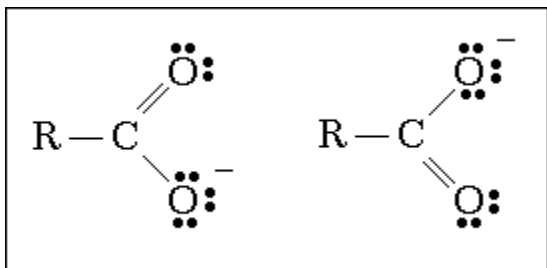




**Resonance effect or Mesomeric effect/Conjugative effect:** Properties of a compound cannot explain by a single Lewis structure. Two or more structure assigned to the compound which differs in the arrangement of electrons of a pi bond or lone pair of electrons but none of them represents true (Real) structure of a molecule. These hypothetical structures are called as resonating or canonical structures. Phenomenon is known as resonance and effect is called as resonance or mesomeric or conjugative effect. It is permanent effect. Example 1)

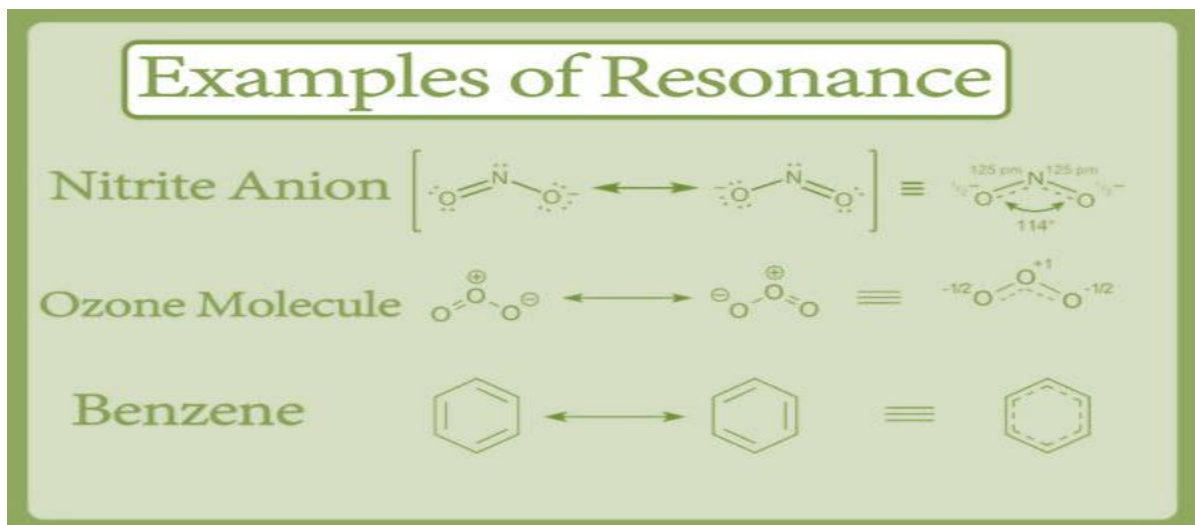


Structure 2) canonical structures of acetate anion.

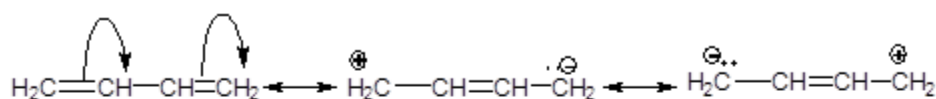


Above the canonical structures are not real structures of acetate anion, its true structure is not adequately represented by any single structure. Hence real structure represented by non conventional Lewis structure that is **resonance hybrid**.

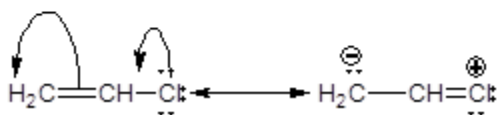
Example 2)



Example 3)

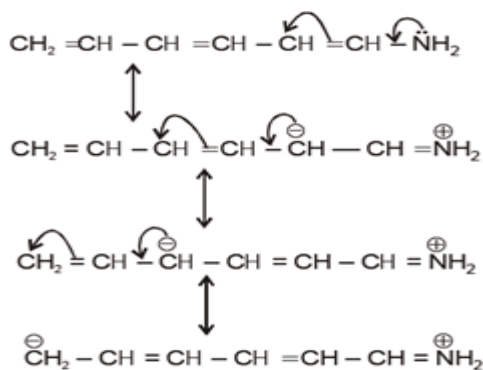


and canonical forms of vinyl chloride are

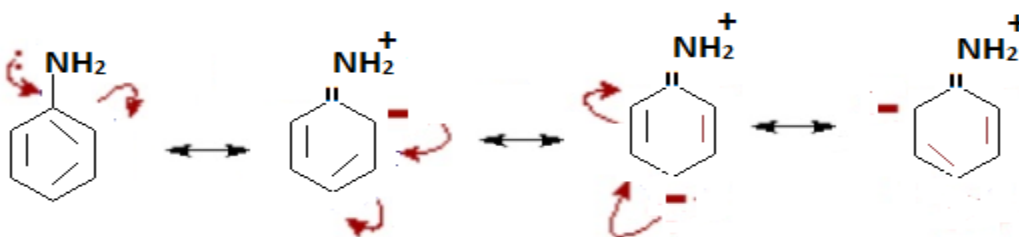


The polarity developed between atoms of a conjugated system by the electron transfer or pi-bond electron transfer is known as the Mesomeric effect. In simple terms, we can describe mesomeric effect occurs when  $\pi$  electrons move away from or towards a substituent group in a conjugated orbital system. There are two types of mesomeric effects..

**+M effect (Positive mesomeric effect)** When the electrons or the pi electrons are transferred from a particular group towards conjugate system, thus increasing the electron density of the conjugated system then such a phenomenon is known as (+M) effect or positive mesomeric effect. Example 1)



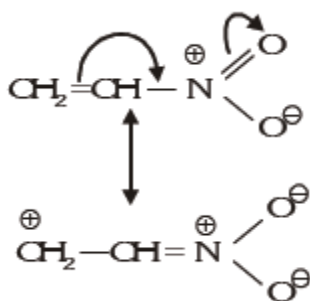
Example 2)



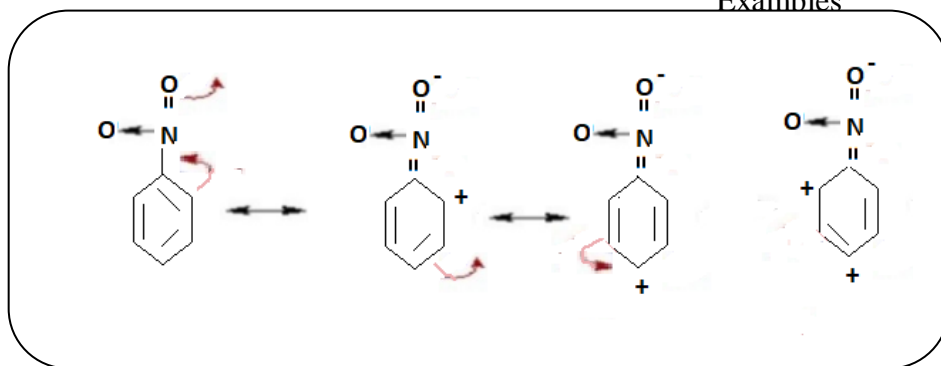
### -M Effect (Negative mesomeric effect):

When the pi-bond electrons are transferred from the conjugate system to a particular group thus the electron density of the conjugate system is decreased, then this phenomenon is known as negative mesomeric (-M) effect.

1)



Examples

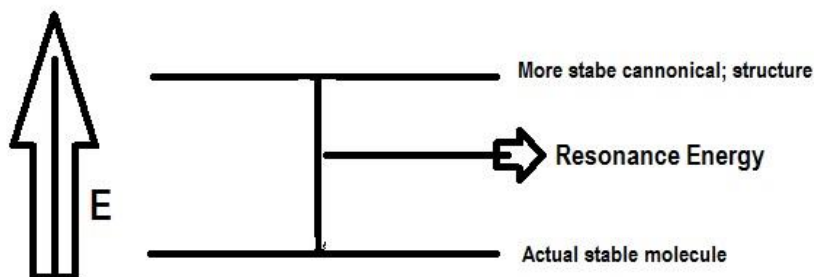


Resonance effect or Mesomeric effect is permanent effect and they affect the physical as well as chemical property of the compound. Resonance refers to delocalization of electrons in a given system. Mesomeric effect is the electron donating or withdrawing nature of a substituent due to resonance.

Resonance hybrid structure is more stable than other canonical structures. It is denoted by double headed arrow.  $\longleftrightarrow$

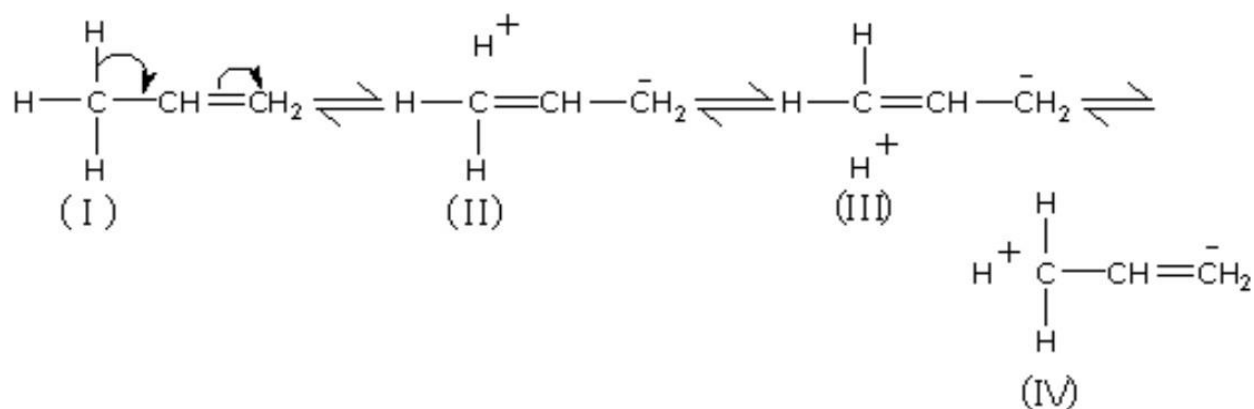
**Conjugative effect** is observed in Conjugated system which is a system of connected p orbital with delocalized electrons in a molecule, which in general lowers the overall energy of the molecule and increases stability. It is conventionally represented as having alternating single and multiple bonds.

The difference in energy between the actual molecule and the canonical form of the lowest energy is called as **resonance energy**.



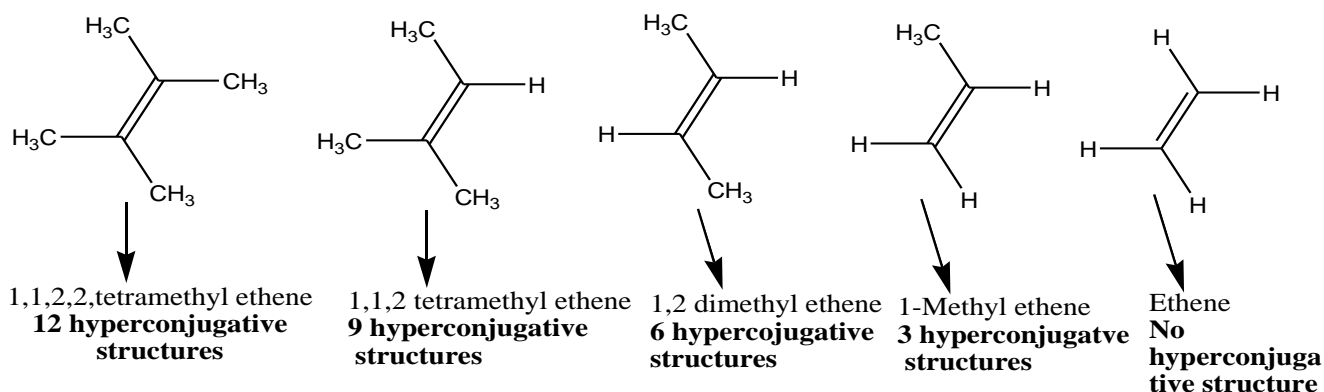
**Hyper conjugation effect:** There are certain organic compounds which are **stabilized due to conjugation involving sigma electrons**. This type of extended conjugation involving sigma bond orbital (electrons of sigma bond), generally of **C-H or C-X bond** (X= halogens) is called as hyper conjugation. Hyper conjugation effect is a permanent effect.

**In propene molecule**

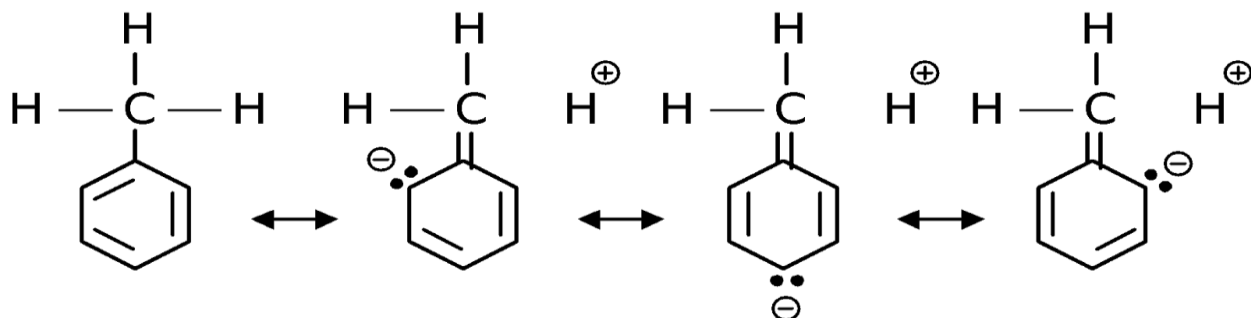


- 1) Structure II, III and IV are resonating structures, there is a covalent bond between carbon and hydrogen atoms.
- 2) These structures possess less number of covalent bonds than the main uncharged structure -I.
- 3) Hence this type of hyper conjugation is also called as **no bond resonance** and resonating structures are called as **hyper conjugative structures**.
- 4) Due to this effect **ionic character** of C-H sigma bond and partial delocalization of its electrons **increases**.
- 5) Hyper conjugation **decreases the bond length**.
- 6) More the resonating structures more is the stability to the molecule.
- 7) For example Propene (3 hyper conjugative structures) is more stable than ethane (no hyper conjugative structure).

Examples are 1)



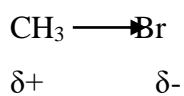
2) In **Toluene** stability can be explained by following hyper conjugative structures.



**Inductive effects:** Covalent bond between two atoms differs in their electronegativities. Thus electrons are shifted towards more electronegative atoms, as a result  $\delta+$  and  $\delta-$

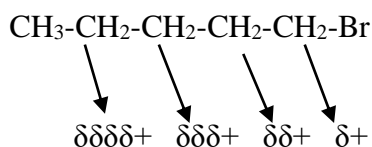
**Permanent displacement of electrons in a sigma bond** due to presence of electronegative atom or group and formation of partial polar molecule is called as inductive effect denoted by 'I' and represented by  $\longrightarrow$  arrowhead pointing towards more electronegative atom.

For example in methyl bromide, due to inductive effect of Br atom,  $\text{CH}_3\text{Br}$  in ground state becomes a partial polar molecule. Hence  $\text{CH}_3$  will bear  $\delta+$  charge and Br shows  $\delta-$  charge.



- 1) It is **permanent effect** and always transmitted along a chain of carbon atoms.
- 2) It **decreases as the distance** from the electronegative atom increases. Generally inductive effect diminishes beyond carbon atom number four.

For example, in 1-bromo pentane,

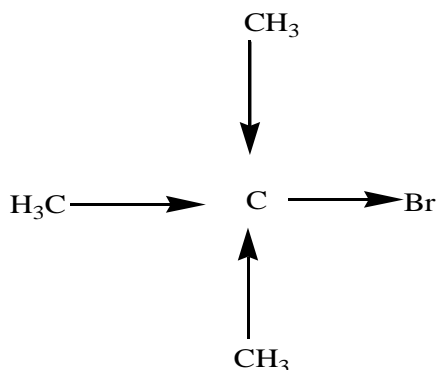


- 3) There are **two types** of Inductive effects

A) **+Inductive effect (+I):** Electron releasing (repelling) groups like  $-\text{CH}_3, -\text{C}_2\text{H}_5, -(\text{CH}_3)_2\text{CH}, -\text{OCH}_3$  etc. are said to exhibit +I effect.

B) **- Inductive effect (-I):** Electron attracting (withdrawing) groups like  $-\text{NO}_2$ , halogens,  $-\text{CHO}, >\text{C}=\text{O}, \text{SO}_3\text{H}, -\text{CN}, \text{RCOOR}$  etc. are said to exhibit -I effect.

Example



In the above example both effect observed one is +I, due to electron donating nature of  $\text{CH}_3$  group and second one is due to presence of  $\text{-Br}$  atom produces  $\text{-I}$  effect on central carbon atom.

### Applications of Inductive effect:

- 1) **Effect of bond length:** Inductive effect produces ionic character in the bond. The bond length of covalent bond decreases with increase in inductive effect due to presence of more electronegative atom or group.

Example	1) $\text{H}_3\text{C-I}$	2) $\text{H}_3\text{C-Br}$	3) $\text{H}_3\text{C-Cl}$	4) $\text{H}_3\text{C-F}$
Bond length	$2.14 \text{ \AA}$	$1.94 \text{ \AA}$	$1.78 \text{ \AA}$	$1.38 \text{ \AA}$

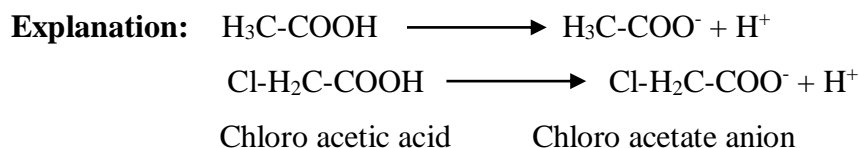
- 2) **Dipole moment:** Dipole moment increases with increase in inductive effect.

Example	1) $\text{H}_3\text{C-I}$	2) $\text{H}_3\text{C-Br}$	3) $\text{H}_3\text{C-Cl}$
Dipole moment	1.64 D	1.79 D	1.83 D

- 3) **Strength of Carboxylic acids:**

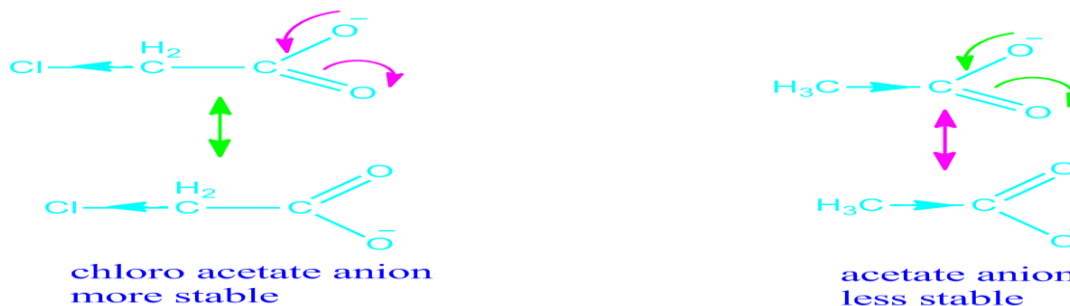
**Case I)** when electronegative substituent particularly attached to the alpha ' $\alpha$ ' carbon atom of carboxylic acid ( $\text{-I}$  effect).

For example 1) **Monochloroacetic acid is 100 times more acidic than acetic acid.**



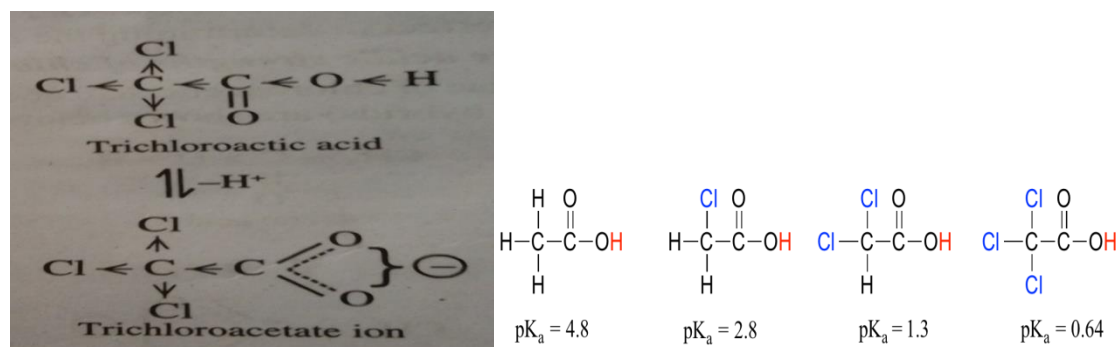
Due to  $(-)$  inductive effect of electronegative chlorine atom, **electrons on oxygen atom** of chloro acetate anion are **more delocalized** resulting in **more stability** of mono chloro acetate anion.

But in case of acetic acid, due to  $(+I)$  effect of  $\text{-CH}_3$  group, electrons on oxygen of acetate anion are less delocalized resulting in less stability of acetate anion and hence less acidic than mono chloro acetic acid.



For example 2) **Tri chloro acetic acid is 7000 times more acidic than acetic acid.**

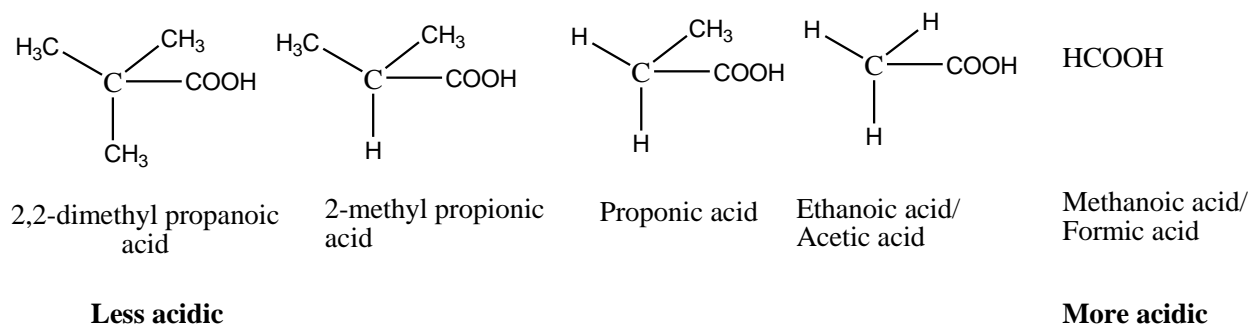
**Explanation:** The greater number chlorine (Three Chlorine) atoms produces most stable trichloro acetate ion, due to electrons on oxygen atom of tri chloro acetate anion are more stabilized which results more stability for tri chloro acetate anion.



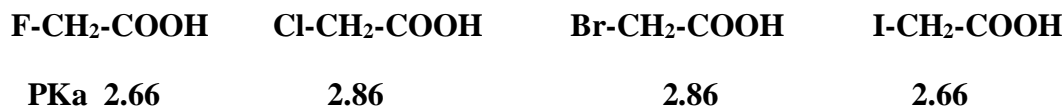
**Case II) 2, 2 –dimethyl propanoic acid is less acidic than methanoic acid OR Methanoic acid is more acidic than 2,2-dimethyl propanoic acid.**

**Explanation:** The presence of greater number of alkyl groups on alpha 'α' carbon atom of carboxylic acid (+I effect). Due to +I effect **destabilize the corresponding carboxylate anion** resulting less ionization of carboxylic acid in the solution.

For example: Increasing order of acidity of alkyl substituted acetic acid can be represented as,



**Example 3) Acidity of Fluroacetic acid is greater than iodoacetic acid.**



**Explanation** Fluroacetic acid is more acidic than chloroacetic acid, which is more acidic than bromoacetic acid....In these halo acids, the halogen can stabilize the conjugate anion



via inductive delocalization. In an inductive effect, electronegative atom can draw electron density toward them and stabilizes to anion.

**Hydrogen Bonding:** As hydrogen atom possess 1s orbital with one electron thus expected to form only one covalent bond but it has been found to possess special ability to form a link between two electronegative atoms.

One link is in the form of polar covalent bond with one electronegative atom and another link is in the form of electrostatic attraction with another electronegative atom (represented in the form of dotted line).

In a polar covalent bond between hydrogen atom and highly electronegative atom, due to uneven sharing of electrons, partial positive charge ( $\delta^+$ ) develops on hydrogen atom which electrostatically attracts negative end of a group of the same or other molecules forming a weak bond.

This type of weak bond formed due to dipole-dipole attraction is called a hydrogen bond and is usually represented by dotted line.

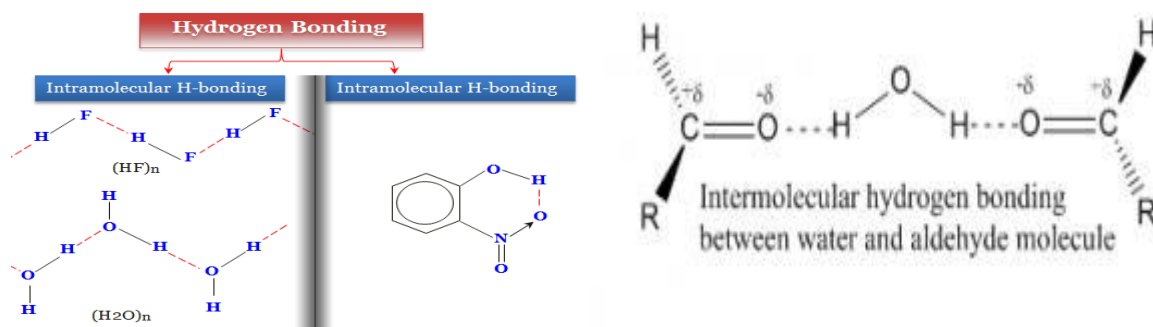
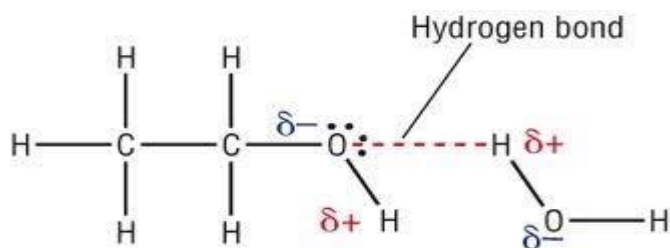
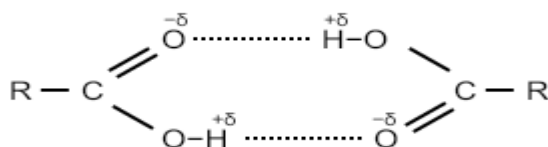
As Hydrogen bond is being as electrostatic in character, it is weaker (Bond energy 3-10 Kcal/mole) than a covalent bond (Bond energy 50-100 Kcal/mole).

Generally hydrogen bond is formed with more electronegative atoms like oxygen, Nitrogen, Sulphur and Fluorine There are two types of Hydrogen bonding..

**A) Intermolecular hydrogen bonding:**(within different molecules) When hydrogen bonding is observed in different molecule which exists in alcohols, carboxylic acids, amines, HF and other compounds also.

**For example** In O-H group of alcohols, due to difference between electronegativity of oxygen and hydrogen atoms, O-H bond becomes polar covalent bond developing partial negative charge on oxygen and partial positive charge on hydrogen (O-H). This partial positively charged H atom attracts  $-ve$  oxygen atom of another alcohol molecule forming a hydrogen bond. This type of electrostatic attraction between O-H group of alcohol; molecules continues resulting in the formation of intermolecular hydrogen bonding.

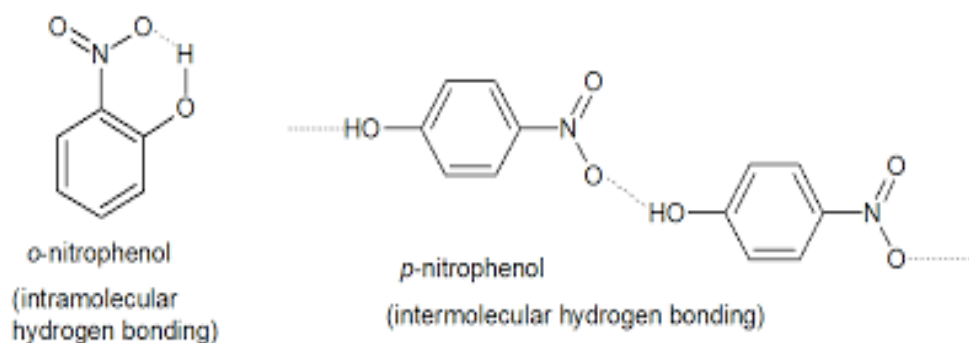
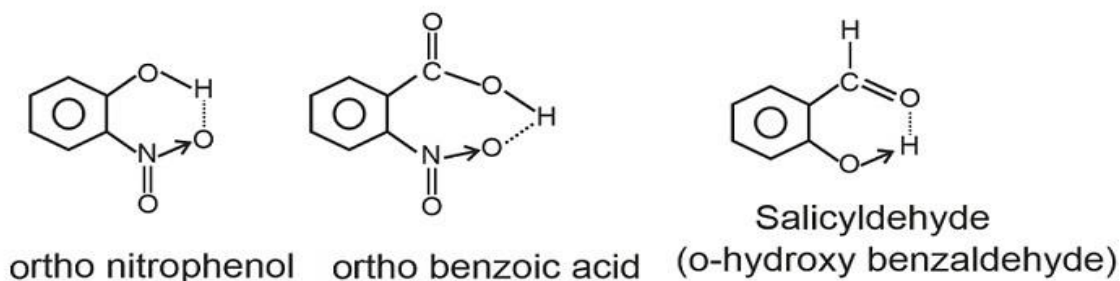
- 1) An **extra energy** is required to break the intermolecular hydrogen bond. This type of bonding **increases the melting and boiling point** of organic molecules.
- 2) A substance is said to be soluble in water, if it is capable of forming hydrogen bonding with water.
- 3) **Alcohols** (O-H) are capable of forming intermolecular hydrogen bonding with **water**.
- 4) **Alkanes, alkenes and alkynes** due to **less electronegativity** difference between carbon and hydrogen atom, do not possess partial polar groups and hence **do not form** intermolecular hydrogen bonding with water molecules.
- 5) Hence alcohols are **more soluble in water** than hydrocarbons.
- 6) Intermolecular hydrogen bonding **increases water solubility** of the organic compound.



**B) Intramolecular hydrogen bonding:**(within same molecules)

It occurs within two atoms of the same molecule. This type of hydrogen bonding is also called as **chelation**.

- 1) It is only possible when two groups are present at ortho positions in the same molecule.
- 2) This type of hydrogen bonding restricts the possibility of intermolecular hydrogen bonding and thus prevents molecular association which would have risen melting and boiling points. Thus due to this Intramolecular hydrogen bonding there is decrease in melting and boiling point.
- 3) For example, the m.pt of o-nitrophenol is  $44^{\circ}\text{C}$ , while m.pt. of p-nitrophenol is  $114^{\circ}\text{C}$ .
- 4) Intramolecular hydrogen bonding decreases solubility of organic compounds in water due to chelation which prevents hydrogen bonding between the water and the compound.
- 5) Examples are,



**Steric effect:** The influence of inductive, conjugative or hyper conjugation effects on the electron availability within the molecule may be modified or nullified by the operation of Steric factor.

**Steric effect** is an influence on a reaction's course or rate determined by the fact that all of the atoms within a molecule occupy space or due to the size of atoms or groups. Thus certain collision paths are either disfavored or favored.

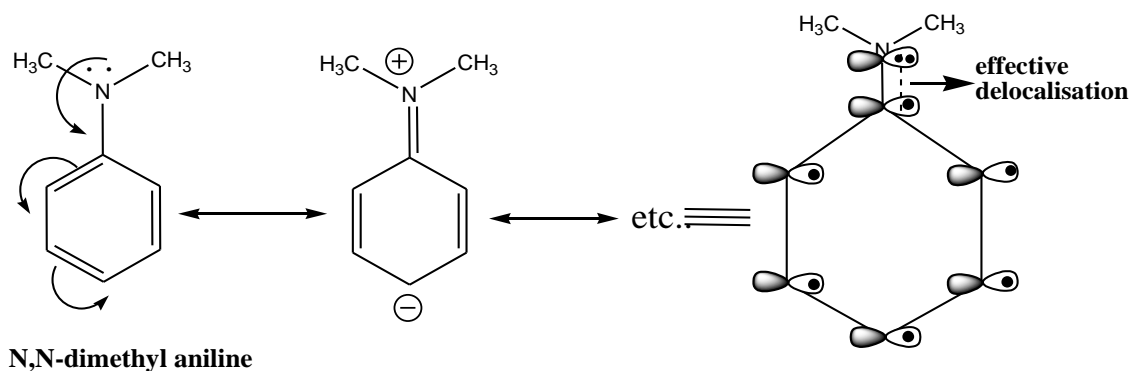
- 1) This effect operates via preventing the effective delocalization of pi-electrons in a molecule or impeding (incoming) the approach of a reagent to the reacting centre by bulky groups.
- 2) Example 1) **Why 2,6-dimethyl N,N-dimethyl aniline is more basic than N,N-dimethyl aniline ?**

**Explanation: A)** In this case both molecule possess lone pair of electron on nitrogen atom .In N,N dimethyl aniline **lone pair of electrons** on N-atom gets **delocalized** over benzene ring **due to coplanarity** between Pz orbital of N-atom containing lone pair of electrons and Pz- orbitals of benzene ring. Hence lone pair of electrons on N-atom of N,N dimethyl aniline is not readily available for basicity of this compound.

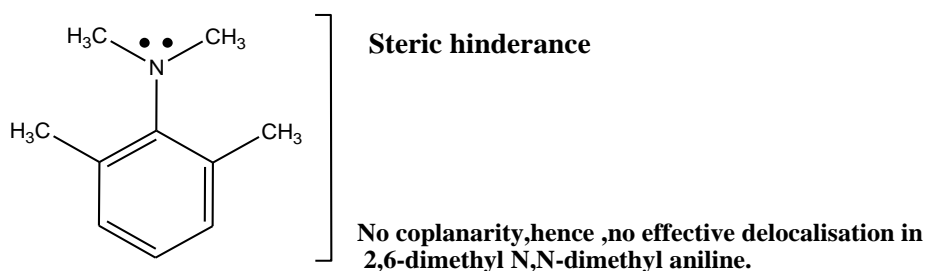
**B)** In **2,6-dimethyl N,N dimethyl aniline**, due to presence of **two bulky  $-\text{CH}_3$**  groups at 2 and 6 positions (at ortho position with respect to  $(\text{CH}_3)_2\text{N}$  group), as a result of Steric hindrance, Pz orbital of N atom containing lone pair of electrons and Pz orbital's of benzene ring are **prevented** from becoming parallel to each other and **sidewise overlapping is inhibited**.

**C)** As **co planarity for effective delocalization is disturbed**, lone pair of electrons on N atom of this compound does not get delocalized over the benzene and remains available on N atom to increase its basic strength.

**D)** Hence 2,6-dimethyl N,N dimethyl aniline is more basic than N,N dimethyl aniline. It is shown by presenting structure of both molecules....



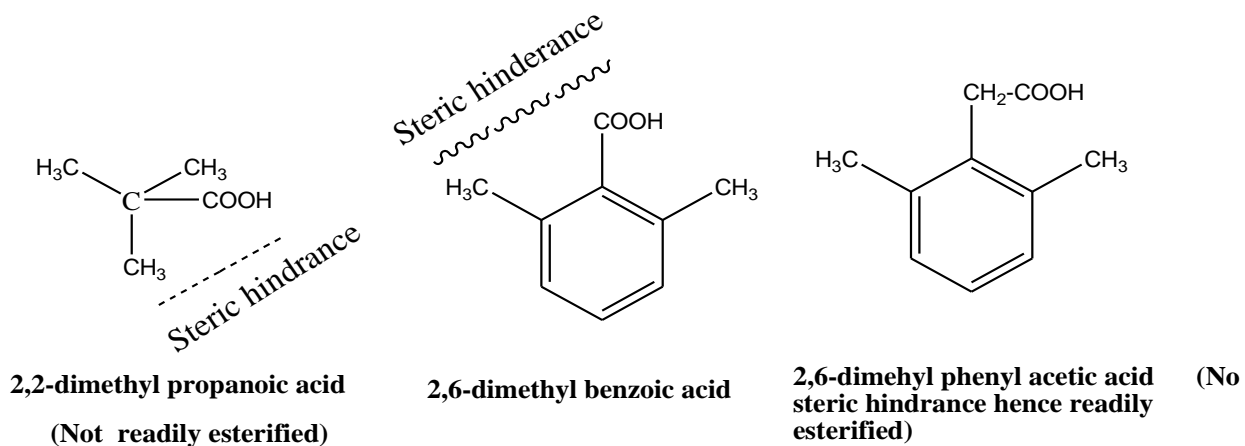
### Effective delocalization in N,N- dimethyl aniline



### Example 2) Esterification of aromatic acids:

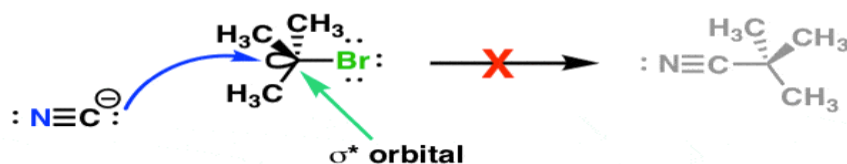
**Why 2,2-dimethyl propanoic acid and 2,6-dimethyl benzoic acid are not readily esterifies?**

This Esterification is not undergoes readily because  $-\text{COOH}$  group in both compounds is sterically hindered by the adjacent two bulky methyl groups. But 2,6- dimethyl phenyl acetic acid is readily esterifies because  $-\text{COOH}$  group is beyond Steric hindrance range of  $-\text{CH}_3$  substitutes due to the presence of  $-\text{CH}_2$  group in between them.



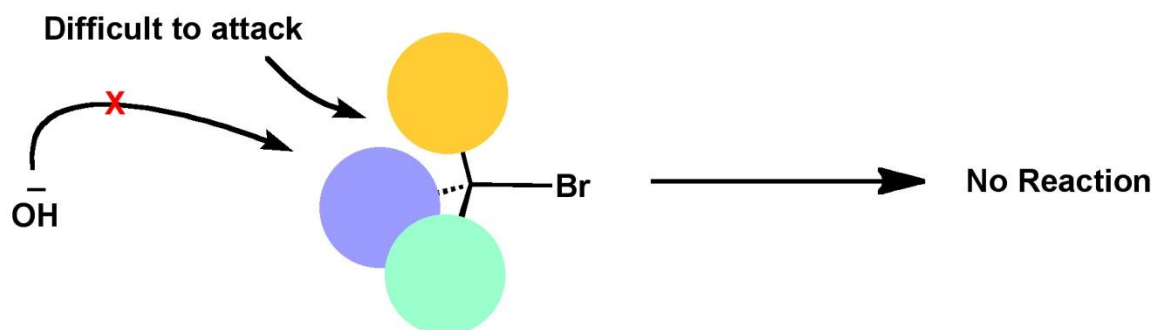
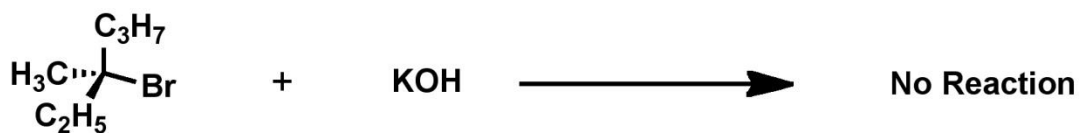
Example 3) Nucleophilic substitution reaction with cyanide:

It's hard for nucleophiles to reach the sigma star orbital of tertiary alkyl halides due to the presence of the bulky methyl groups.



• This  $S_N2$  reaction of a nucleophile with a tertiary alkyl halide is doomed to fail.

Example 4) Nucleophilic substitution reaction with KOH:





Bharat Shikshan Sanstha's  
**Shri Chhatrapati Shivaji College, Omerga**

Tq. Omerga Dist. Osmanabad - 413606 (MS), India

(Affiliated to Dr. Babasaheb Ambedkar Marathwada University, Aurangabad) | NAAC Reaccredited 'B' Grade

DEPARTMENT OF CHEMISTRY

**Question Bank**

Class: B.Sc. Semester -I

**Name of Paper:** Organic Chemistry (Paper -II) CHE-102

**Title of Chapter:** Structure and Bonding

**Questions**

1. What is resonance? What are main conditions of resonance/write resonating structure of acetate anion?
2. Explain hyper conjugation? How will you explain the more stability of 2,3-dimethyl-2-butane than 2-butane by hyper conjugative effect?
3. What is inductive effect? Explain with suitable examples, the effect of inductive effect on strength of carboxylic acids?
4. What is Hydrogen bond? Explain different types of hydrogen bonding and their effect on M.Pt. and B.Pt. of organic compounds?
5. Write a note on charge transfer complexes?
6. Why propene is more stable than ethane?
7. Why monochloroacetic acid is stronger acid than acetic acid?

**8. Explain the Following**

- A) The presence of greater number of alkyl groups at alpha carbon atom of a carboxylic acid decreases the acidity of a carboxylic acid?
- B) 2,6-Dimethyl-N,N-dimethylaniline is more basic than N,N-dimethylaniline even though nitrogen atoms of both compounds possess lone pair of electrons.

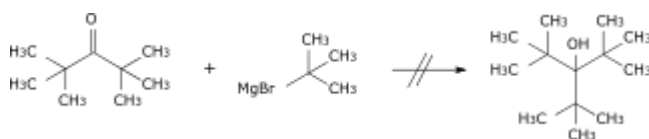
- C) 2,6-dimethyl benzoic acid is difficult but 2,6-dimethyl phenyl acetic acid can be easily esterifies?
- D) Alcohols are water soluble while higher alkanes are water insoluble?
- E) M.P. of o-nitrophenol is 44<sup>0</sup>C while M.P. of p-nitrophenol is 114<sup>0</sup>C?
- F) Picric acid can form picrate with benzene as addition compound?
- G) Why trichloroacetic acid is 7000 times stronger acid than monochloroacetic acid?

**9) Write short notes on followings:**

- A) Steric effect
- B) Charge transfer complexes
- C) Effect of Inductive effect on strength of carboxylic acids
- D) Hyperconjugation
- E) Intermolecular and Intramolecular hydrogen bonding
- F) Localized and delocalized chemical bonding
- G) Effect of steric hinderence on reactivity of compounds

**Multiple choice Questions**

1. Which of the following corresponds to an observed phenomenon that when atoms that are forced to come close together and occupy the same space the energy of the system is overall increased?
- A. Electronic effect
- B. Steric effect
- C. Resonance effect
- D. Delocalization effect
2. Why won't the following reaction take place as shown?



- A) The two reactants are too sterically hindered i.e. there's too much steric strain with each reactant
- B) The Grignard reagent isn't reactive enough
- C) The ketone needs to be activated more



D) There's no catalyst present

3. All bonds in benzene are equal due to.....

A) Tautomerism

B) Inductive effect

C) Resonance effect

D) Isomerism

4. Inductive effect is \_\_\_\_\_.

A) Temporary

B) Permanent

C) Always temporary but permanent in specific condition

D) None of these.

5. Which one of the following orders is correct regarding the -I effect of substituent's?

A)  $\text{NR}_2 < \text{OR} < \text{F}$

B)  $\text{NR}_2 > \text{OR} > \text{F}$

C)  **$\text{NR}_2 < \text{OR} < \text{F}$**

D)  $\text{NR}_2 > \text{OR} < \text{F}$

6. Polarization of sigma bond caused by polarization of adjacent sigma bond is..

A) Mesomeric effect

B) Resonance effect

C) **Inductive effect**

D) none of these.

7. Which of the following occurs due to electronegativity difference?

A) Mesomeric effect

B) Resonance effect

C) **Inductive effect**

D) None of these

8. Choose correct decreasing order of -I effect..

A)  **$\text{NO}_3 > \text{F} > \text{OCH}_3 > \text{C}_6\text{H}_5$**

B)  $\text{NO}_3 > \text{OCH}_3 > \text{F} > \text{C}_6\text{H}_5$

C)  $\text{NO}_3 > \text{F} > \text{C}_6\text{H}_5 > \text{OCH}_3$

D)  $\text{NO}_3 > \text{C}_6\text{H}_5 > \text{F} > \text{OCH}_3$

9. State whether the following statements are True or False? Explain your choice.

i) Inductive effect is the ability of an atom or a group of atoms to cause polarization of electron density along the covalent bond so that the atom of higher electronegativity becomes electron deficient.

Ans: **False.** Inductive effect is the ability of an atom or a group of atoms to cause polarization of electron density along the covalent bond, but the atom of higher electronegativity acquires slightly higher electron density and becomes  $\delta^-$ .

ii) The  $-\text{OH}$  group cannot exhibit Inductive effect.

Ans: **False.**  $-\text{OH}$  group can exhibit mesomeric effect through donation of the lone pair when it is bonded to a  $\text{sp}^2$  carbon, at the same time the oxygen through its higher electronegativity can show Inductive effect. But the mesomeric effect when it is prevalent is predominating.

iii) Inductive effect can be responsible for the dipole moment in a molecule.

Ans: **True.** Dipole moment is charge times the distance separating the charge, Inductive effect causes charge separation hence will have dipole moment. There are however examples of molecules which have charge separation in a bond but the molecule has net zero dipole moment due to symmetry induced cancellation.

iv) All alkyl groups exhibit  $-I$  effect.

Ans: **False.** All alkyl groups exhibit  $+I$  effect. An alkyl group pushes electron density away from itself towards the carbon to which it is attached.

10. Select incorrect statement(s):

A) Electron-withdrawing inductive effect to the carbonyl group in  $-\text{COOH}$  group weakens the  $\text{O}-\text{H}$  bond and favors ionization of a carboxylic acid compared with an alcohol

B) Inductive effect of the chlorine destabilizes the acid and stabilizes the conjugate base

C) Aniline is a weaker base than ammonia

**D) Phenol is a weaker acid than water.**

11. The  $+I$  effect is shown by

A)  $-\text{CH}_3$

B)  $-\text{OH}$

C)  $-\text{F}$

D)  $-\text{C}_6\text{H}_5$

12. The - I effect is shown by
- A)  $-\text{COOH}$
  - B)  $-\text{CH}_3$
  - C)  $-\text{CH}_3\text{CH}_2$
  - D)  $-\text{CHR}_2$
13. The boiling point of water is exceptionally high because
- A) there is a covalent bond between H and O
  - B) water molecule is linear
  - C) **water molecules associate due to hydrogen bonding**
  - D) water molecules are not linear.
14. Which one of the following elements is least likely to participate in a hydrogen bond?
- A) O
  - B) F
  - C) **S**
  - D) N
15. Which one of the following represents the weakest interaction between two species?
- A) Hydrogen bond
  - B) Disulfide bond
  - C) Ionic bond
  - D) **Dispersion force**
16. Which of the following compounds has the highest boiling point?
- A) Methane  $\text{CH}_4$
  - B) Ethane  $\text{C}_2\text{H}_6$
  - C) **Ethanol  $\text{CH}_3\text{CH}_2\text{OH}$**
  - D) Dimethyl ether  $\text{H}_3\text{C}-\text{O}-\text{CH}_3$
17. **True or false:**
- A hydrogen bond forms a stronger chemical bond than a covalent bond.
18. In a water molecule, which atom(s) has/have a partial negative charge?
- A) Oxygen
  - B) Hydrogen
  - C) None of the atoms

D) All of the atoms

19. Hydrogen bonding occurs in molecules when \_\_\_\_\_.

A) Hydrogen atom forms a covalent bond with another atom.

B) Hydrogen atom in a molecule forms a bond with any atom.

C) Hydrogen atoms form an ionic bond with another atom on an adjacent molecule.

D) Hydrogen atom bonded to F, O or N is attracted to an electron pair on a F, O or N atom on an adjacent molecule.

20. Which of the following is correct for formation of hydrogen bond...

A) -O-H-O-H-X

B) **-O-H-----O-X**

C) -O-H-----H-O-X

D) -O-H-----C-O-X

21. Which of the following statement is true? The number of intermolecular hydrogen bonds between water molecules will be...

A) **Maximum in ice and minimum in water vapor**

B) Maximum in liquid water and minimum in water vapor

C) Minimum in liquid water and maximum in water vapor

D) Same in ice, liquid water and water vapor

22. Non polar molecules are insoluble in water. This is because....

A) Non polar molecules are uncharged

B) Non polar molecules cannot be ionized

C) Non polar molecules unable to form water-solute interaction

D) **Hydrogen bonding is not possible with non polar molecules.**

