INDUCTIVE EFFECT

When covalent bond is formed in between two similar atoms, the electron pair occupies central position between the two nuclei of the atoms and such bond is known as Non-polar covalent bond.

eg. H:H Cl:Cl

When covalent bond is formed in between two dissimilar atoms the electron pair forming the σ bond is never shared absolutely equally between the two atoms. But it is attached a little more towards the more En ~~atom~~ element.

eg: In compound C–X, where X is more En than C. The electron pair more attracted towards atom X. With the result it attains a partial negative charge denoted by (–δ) while C-atom attains a partial positive charge denoted by (+δ)

$$-\overset{|}{\underset{|}{C}}:X \quad \text{or,} \quad -\overset{|}{\underset{|}{C}}\overset{+\delta}{-}X^{\delta-}$$

On the other hand, in compound C–Y, where Y is electropositive element or group i.e. C is more En than Y. The electron pair forming the C–Y bond is same that displaced towards the C-atom and thus C and Y attain partial-ve or +ve charges respectively.

$$-\overset{|}{\underset{|}{C}}:Y \quad \text{or,} \quad -\overset{|}{\underset{|}{C}}\overset{+\delta}{-}Y^{\delta-}$$

Inductive effect now may be defined as the permanent displacement of electron forming a covalent towards the more En element or group.

It is important to note that the electron pair, although permanently displaced or simply shifted but remains in same valency shell. The inductive effect is always transmitted along a chain of C-atoms.

When an electron withdrawing atom such as X or group (–NO_2, –CN, –COOH) etc. are attached to the end of a C-chain the σ electron of the bonds are slightly displaced towards more En atom or elect

ron withdrawing group.

However its intensity decreases as distance from source atom increases.

$$C_4 \longrightarrow C_3^{\delta'''} \longrightarrow C_2^{\delta''} \longrightarrow C_1^{\delta'} \longrightarrow Cl^{\delta-}$$

The +ve charge on C_1 attracts the electron pair shared between C_1 and C_2 towards itself. This will cause C_2 to acquire a small +ve charge but this charge on C_2 will smalles than on C_1. Similarly C_3 will also acquire +ve charge that will be still smalles.

Inductive effect is a permanent effect and it is denoted by an arrow head in the middle of covalent bond pointing in the direction of electron displacement ($\longrightarrow$)

There are two types of Inductive effect:

(1) -I effect : The atom or group which has more power to attract electrons in compasison to H is said to be -I effect. The σ electrons ase displaced towards the substituent X

-I effect - Atoms or groups (Electron-attracting or withdrawing)

$-NO_2 > -CN > -COOH > -F > -Cl > -Br > -I > OR > OH > C_6H_5 > CH=CH_2 > H$

(2) +I effect : The atom or group which has less power to attract the electrons than H is said to be +I effect. The σ electrons are displaced away from the substituent Y.

+I effect - group or atoms (Electron releasing or repelling)

$(CH_3)_3C > (CH_3)_2CH > CH_3CH_2 > CH_3 > H$

Features of Inductive effect :

1. Inductive effect brings change in physical properties , dipole moment , solublity etc. It also effect the rate of reaction.

2. The inductive effect is not confined to the polarization of one bond but it is transmitted along a chain of C-atoms through σ bond. However the effect is insignificant beyond second C-atom in chain.

Applications of Inductive effect

Calculate the strength of Carboxylic acid :

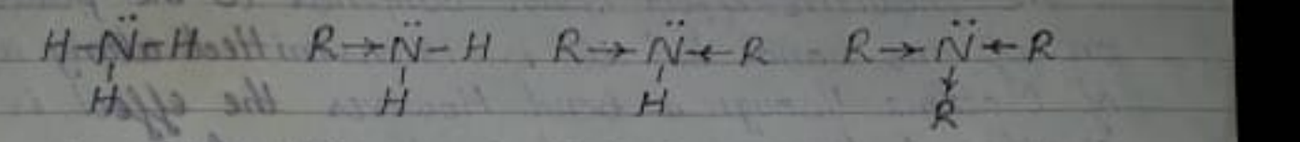
We know that -COOH group is carboxylic acid . The tendency of H-atom replaced easily to form carboxylate ion . If -I effect group are attached with the carboxylic acid then acidity will be increase because H^+ ion more rapidly (Produced) . If +I group are attached with the carboxylic acid the nature of the acid will be weak because H^+ ion not produced quickly in comparison of -I group.

Calculate the strength of the base :

According to Lewis base we know that those substances are base which donate the electron pair of other molecule. Ammonia and amines are basic in nature because N-atom contains lone pair of electron ammonia, amines are basic in nature.

When alkyl group attached with ammonia in place of hydrogen then basicity will be increase because alkyl group shows +I effect . +I effect is electron donating group So, donating capacity of

N- atom increases. Similarly ~~ter amine~~ should be more basic because three alkyl groups attached with N-atom, then sec. amine then primary then ammonia. But it is not true fact basicity of sec. amine is greater all of them primary then tertiary then ammonia due to the steric Hindrance.



Ammonia Pri amine Sec. amine Ter. amine

$R_3N > R_2NH > RNH_2 > NH_3$ Wrong fact

$R_2NH > RNH_2 > R_3N > NH_3$ True fact