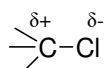
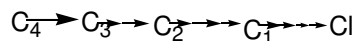


Inductive Effect:

A covalent bond between two atoms contains two electrons. But when the electronegativity of two atoms differ, the two electrons of the covalent bond are not equally shared between two ato. The electron density of the bond is then slightly shifted towards the more electronegative atom making the less electronegative atom partially positive and the more electronegative atom partially negative and the compound can be represented as



Now if we consider a carbon chain where one terminal carbon atom (C_1) is joined to a more electronegative atom say Cl, the electron density of the C_1 -Cl bond will be displaced towards Cl atom acquiring partial negative charge and C_1 a partial positive charge. Since C_1 is now partially positive, it will attract the electron density of the C_1 - C_2 bond. So C_2 will now become partially positive in nature. But the charge on C_2 will be less compared to that on C_1 since the effect of the Cl atom has been transmitted to C_2 through C_1 . This type of effect will be transmitted down the chain but it will be too small to be noticeable beyond C_2 or C_3 .



These types of influences on electron distribution in σ bonds are known as *inductive effects*. Inductive effect is of two types: +I effect and -I effect.

If any atom or group, attached to the carbon is less electronegative than hydrogen, it donates electrons to the C-chain. It is then said to have +I effect. Example, Me, $MeCH_2$, Me_2CH etc. If any atom or group is attached to the carbon is more electronegative than hydrogen, it withdraws electrons from the C-chain towards itself. It is then said to have -I effect. Example, NO_2 , Cl, Br, COOH etc.

TABLE : Inductive Effects of Various Groups

Relative to Hydrogens

+I	-I		
O⁻	NR₃⁺	COOH	OR
COO⁻	SR₂⁺	F	COR
CR₃	NH₃⁺	Cl	SH
CHR₂	NO₂	Br	SR
CH₂R	SO₂R	I	OH
CH₃	CN	OAr	C≡C
D	SO₂Ar	COOR	Ar HC=CR₂

All inductive effects are permanent polarizations in the ground state of a molecule, and are therefore manifested in its physical properties, for example, its dipole moment. It explains the polarity of a covalent bond in organic compounds and thus explains the relative reactivity of alkyl halides as well as that of alkane.

It explains relative acid and base strengths. Acetic acid ($\text{CH}_3\text{-COOH}$) is less acidic than formic acid (HCOOH) due to presence of electron donating CH_3 group which pushes electrons to COOH group so that it can't release proton easily.

Trichloroacetic acid (Cl_3CCOOH) is more acidic than chloroacetic acid (ClCH_2COOH) which is more acidic than acetic acid. The presence of 3 $-I$ effect giving chlorine atoms in trichloroacetic acid relative to 1 chlorine atom in chloroacetic acid is responsible for more acidity in the former compound whereas no such electron withdrawing group is present in acetic acid.

Between 2-Chloropropionic acid and 3-chloropropionic acid, former is more acidic as chlorine is closer to COOH group in the former compound.



Other examples: FCH_2COOH , ClCH_2COOH , BrCH_2COOH , ICH_2COOH

pK_a : 2.7 2.8 2.9 3.0

HOCl , HOBr , HOI

pK_a 7.4 8.7 10.7

Resonance or mesomeric effect:

Electron redistribution which can take place in an unsaturated and especially in conjugated system via their π orbitals, is known as *resonance effect*. It is introduced in organic chemistry to explain some properties of various compounds. Some organic compounds can have more than one structure and none of them can explain entirely satisfactorily the properties. Resonance effect can explain such property. For example,