**What is Hyperconjugation?**

Hyperconjugation is the stabilizing interaction that results from the interaction of the electrons in a σ-bond (usually **C-H** or **C-C**) with an adjacent empty or partially filled p-orbital or a π-orbital to give an extended molecular orbital that increases the stability of the system.

Based on the valence bond model of bonding, hyperconjugation can be described as "double bond - no bond resonance" but it is not what we would "normally" call resonance, though the *similarity* is perhaps useful and is shown below.

**What is the key difference between hyperconjugation and resonance?**

Hyperconjugation involves a sigma orbital component, usually a **C-C** or **C-H** bond.
Resonance involves pi orbitals

Hyperconjugation is a factor in explaining why increasing the number of alkyl substituents on a carbocation or radical center leads to an increase in stability.

|  |  |
| --- | --- |
| Let's consider how a methyl group is involved in hyperconjugation with a carbocation centre.  | interaction of a methyl group |
| First we need to draw it to show the **C-H** σ-bonds. Note that the empty p orbital associated with the positive charge at the carbocation center is in the same plane (*i.e.* coplanar) with one of the **C-H** σ-bonds  (shown in blue.) | look at the sigma bonds |
| This geometry means the electrons in the σ-bond can be stabilized by an interaction with the empty p-orbital of the carbocation center. (this diagram shows the similarity with resonance and the structure on the right has the "double bond - no bond" character) | electrons in the sigma bond interact with the empty p orbital |

* Of course, the **C-C** σ-bond is free to rotate, and as it does so, each of the **C-H** σ-bonds in turn undergoes the stabilizing interaction.
* The ethyl cation has 3 **C-H** σ-bonds that can be involved in hyperconjugation.
* The more hyperconjuagtion there is, the greater the stabilization of the system.
* For example, the t-butyl cation has 9 **C-H** σ-bonds that can be involved in hyperconjugation.
* Hence (CH3)3C+ is more stable than CH3CH2+
* The effect is not limited to **C-H** σ-bonds, appropriate **C-C** σ-bonds can also be involved in hyperconjugation.

**What are Inductive Effects?**

* An **inductive effect** is an electronic effect due to the polarization of **σ bonds** within a molecule or ion.
* This is typically due to an electronegativity difference between the atoms at either end of the bond.
* In a simple alkyl carbocation, the positive C attracts the electrons in the σ bonds connected to that center towards itself and therefore away from the atom at the other end of the σ bond.
* Electrons in **C-C** bonds are more readily polarized than those in a **C-H** bond.
* Therefore, alkyl groups are better at stabilizing C+ than H atoms.