Electroneutrality Principle and Back Bonding (Part 01)

Prepared by Dr. Manash Jyoti Deka

Electron Neutrality Principle

- According to the **electro neutrality principle** given by Pauling, the atoms in a molecule share the electron pairs to the extent such that charge on each of the atom remains close to zero.
- The first attempt to bonding in transition metal complexes was made by Sidgwick who extended the octet theory of G.N. Lewis to coordination compounds. Ligands (lewis bases); metal ion (lewis acid)
- Stability was assumed to be attendant to a noble gas configuration for the metal.
- The sum of electrons on metal + electrons donated from ligands was called eeffective atomic number EAN.
- eg: 36 (Kr), 54 (Xe)

18 electron Rule

- When metal achieves an outershell configuration of ns^2 $(n-1)d^{10}np^6$, there wil be 18 electrons in the valence orbitals and a closed, stable configurtion.

- This rule of thumb, which is referred as the 18 electron rule has the advantage of being the same for all rows of periodic chart, eliminating the need to remmber different EAN for each noble gas.

- Metal carbonyls follow this rule, therefore it has a considerable usefulness as a tool for predicting formulas of stable compounds.

Metal Carbonyls (Synergic Bonding)

- Transition metals in low oxidation state form complex with neutral ligands eg: CO, PR3, alkenes.
- CO → Metal Carbonyl Compounds

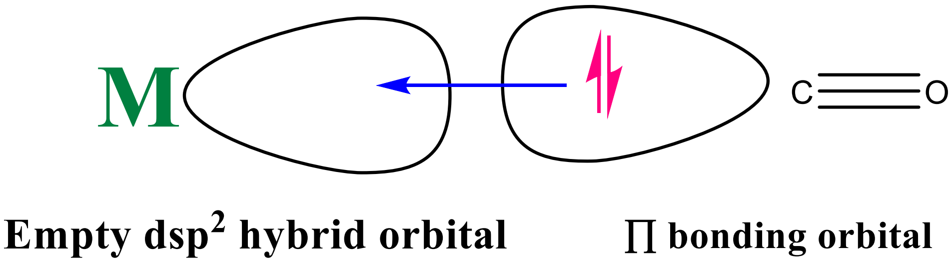
Π ACCEPTOR BONDING MODEL:

- **Metal Centre acts as a lewis acid. CO donates electrons to the metal**

  (M ← CO) Metal Centre σ-Bonding

(Metal lower oxidation State +1, -0, -1)

σ donation

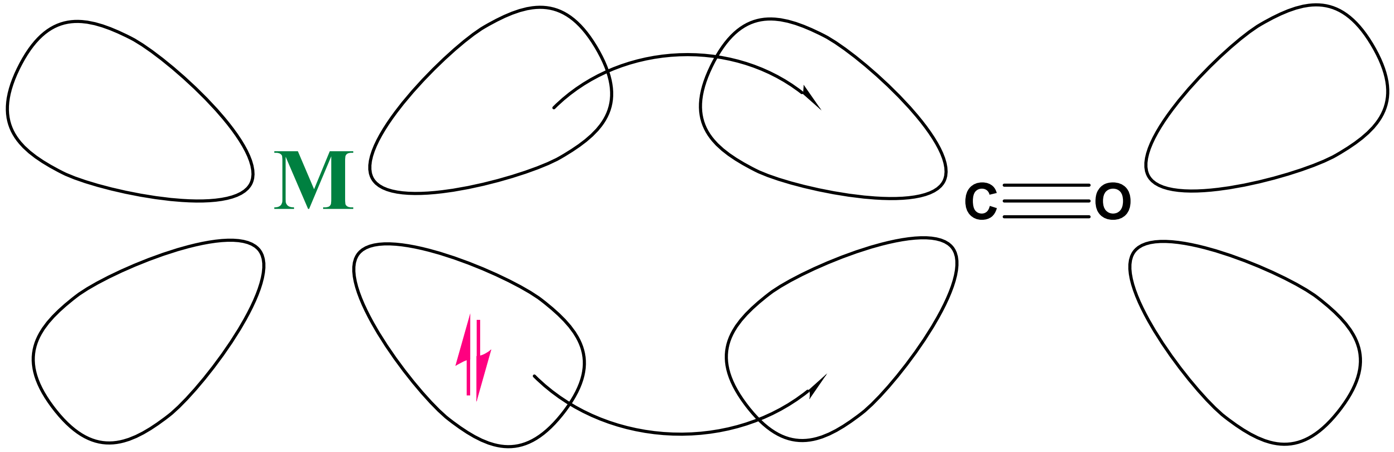


σ bond:

Empty dsp2 hybrid orbital ← ∏ Filled Ligand

Transition metal having filled d orbital back donates electrons into empty antibonding molecular orbital of CO; Π acid complex.

∏ bond: **Filled d orbitals** → **∏* Ligand MO**



Back donation of electrons from filled d orbitals of metal to empty antibonding orbitals of CO

SYNGERGIC BONDING: Energy released when σ bond is formed is reinforced for back bonding. σ donation leads to charge in metal centre which is reinforced back Π back donation.

SYNERGIC BONDING IN METAL CARBONYLS

As a result of synergic bonding, M-C bond strength increases, while $\mathbf{C\equiv O}$ bond strength decreases.

Metal Carbonyl	**IR Stretching Frequency (cm-1)**	**Charge on complex**
$[Mn(CO)_6]^+$	2090	+1
$[Ni(CO)_4]$	2060	0
$[Cr(CO)_6]$	2000	0
$[Co(CO)_4]^-$	1890	-1
$[Fe(CO)_4]^{2-}$	1790	-2

$CO > MCO > M_2CO > M_3CO$

2143 2090-2000 1900-1750 1800-1600

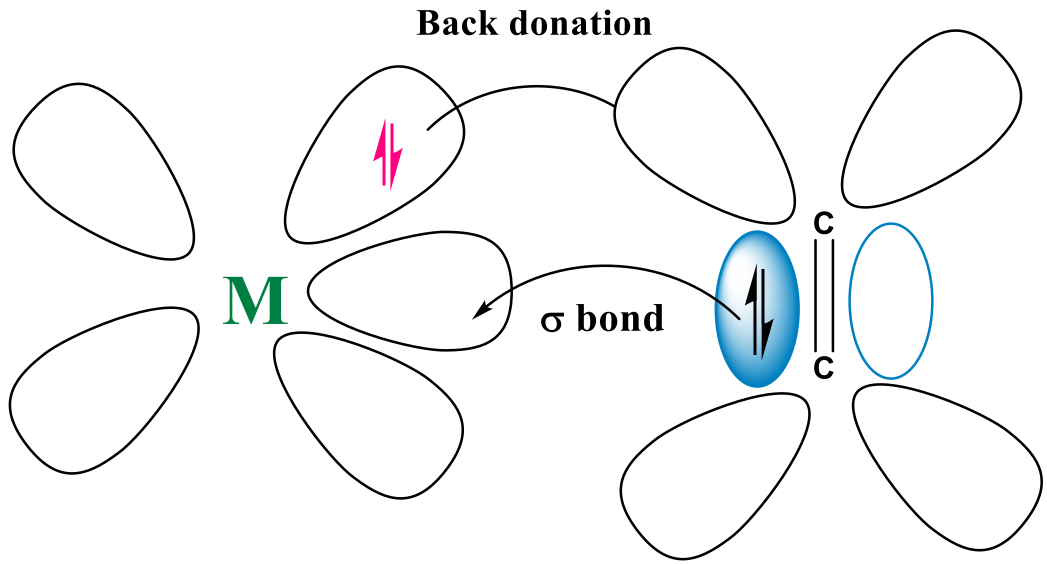
$C\equiv C$

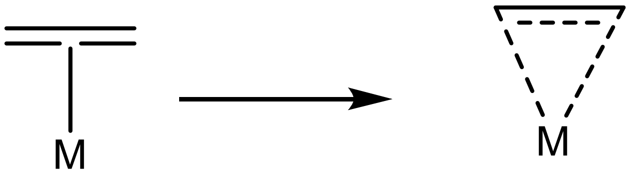
Alkyne

$H_2C=CH_2$

Alkene

Act as σ donor





3 centered bond

Dewar Chatt Duncansen Model