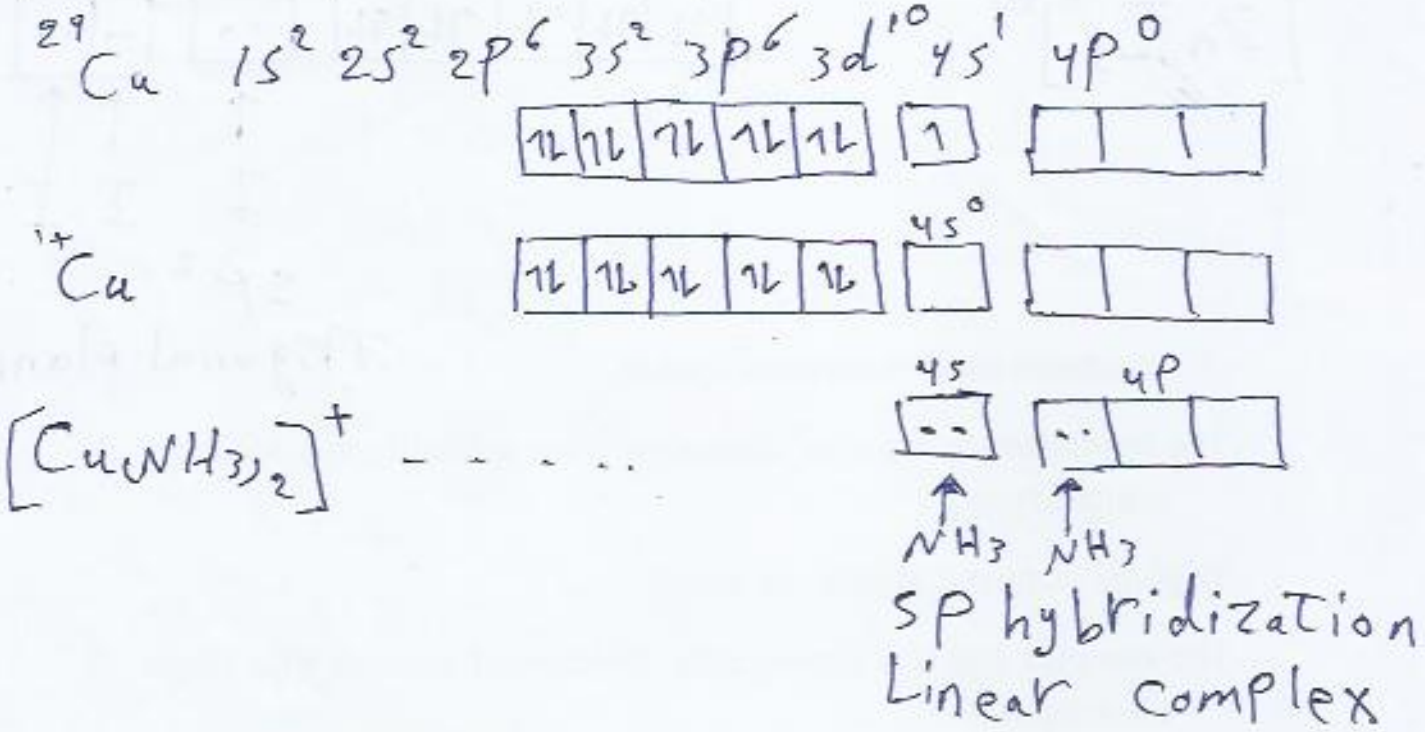
Valence bond theory نظرية اصرة التكافؤ

This theory is applied to the coordination compounds, which are closely related to the hybridization and geometrical shape of the central atom. This theory represents the metal orbitals in squares (or circles) to show the distribution electron of the outer shell of the metal (Lewis acid), which has the ability to accept a pair of electrons, (Lewis base) have the ability to give a pair of electrons and formation coordination bond between the ligand and the metal.

Example 1: The complex ion of the copper diamine $[Cu(NH_3)_2]^+$ the electronic structure of the outer shell of the copper and the electronic structure of the complex shall be as follows:



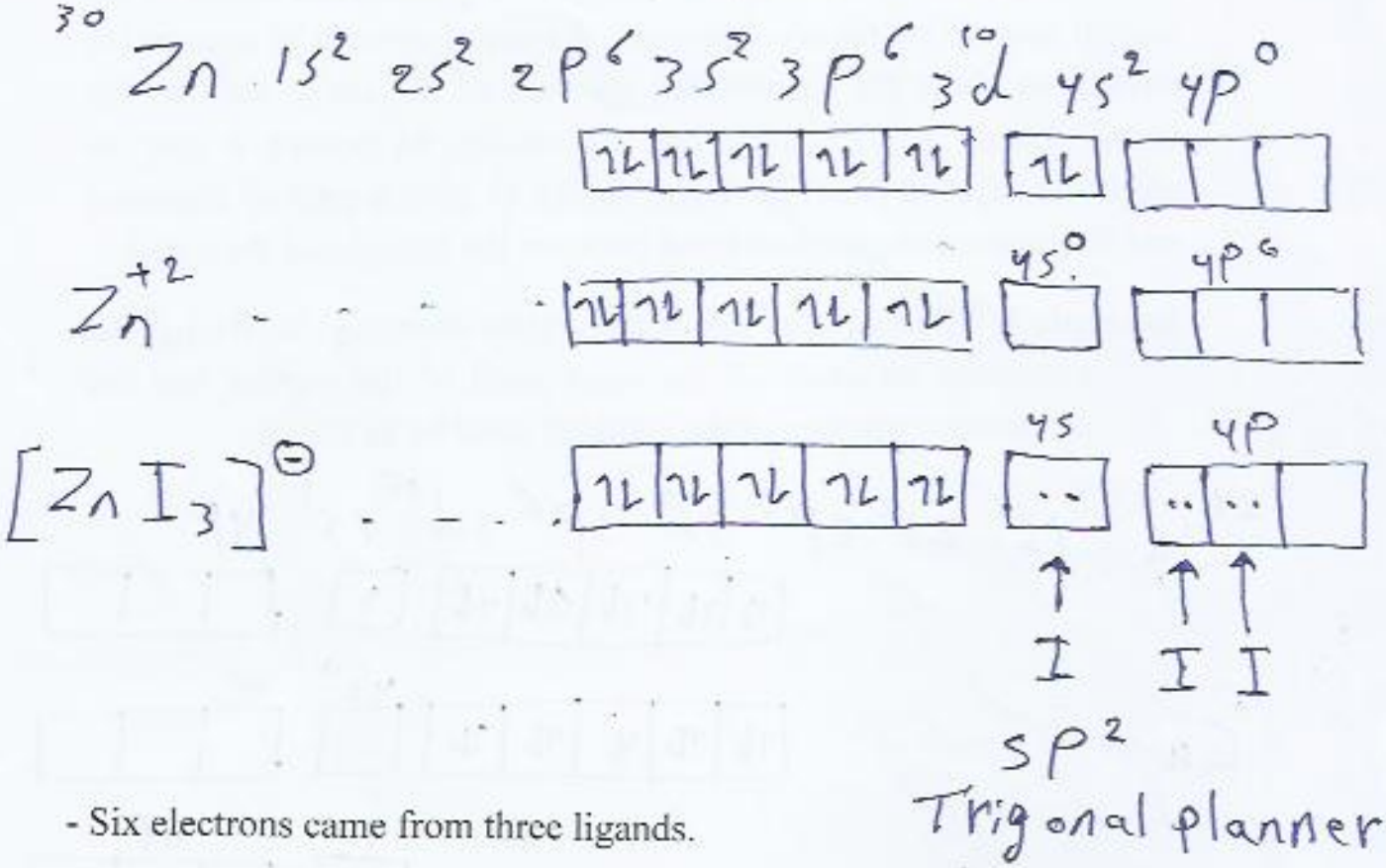
- Four electrons came from two ligands.

-The hybridization type sp formation from orbital type s with orbital type p .

-Linear complex ion shape.

-The complex ion is a diamagnetic because of absence of a single electron in it.

Example 2: The complex ion of the triiodo zinc (II) $[ZnI_3]^-$ the electronic structure of the outer shell of zinc metal and the electronic structure of the complex shall be as follows:



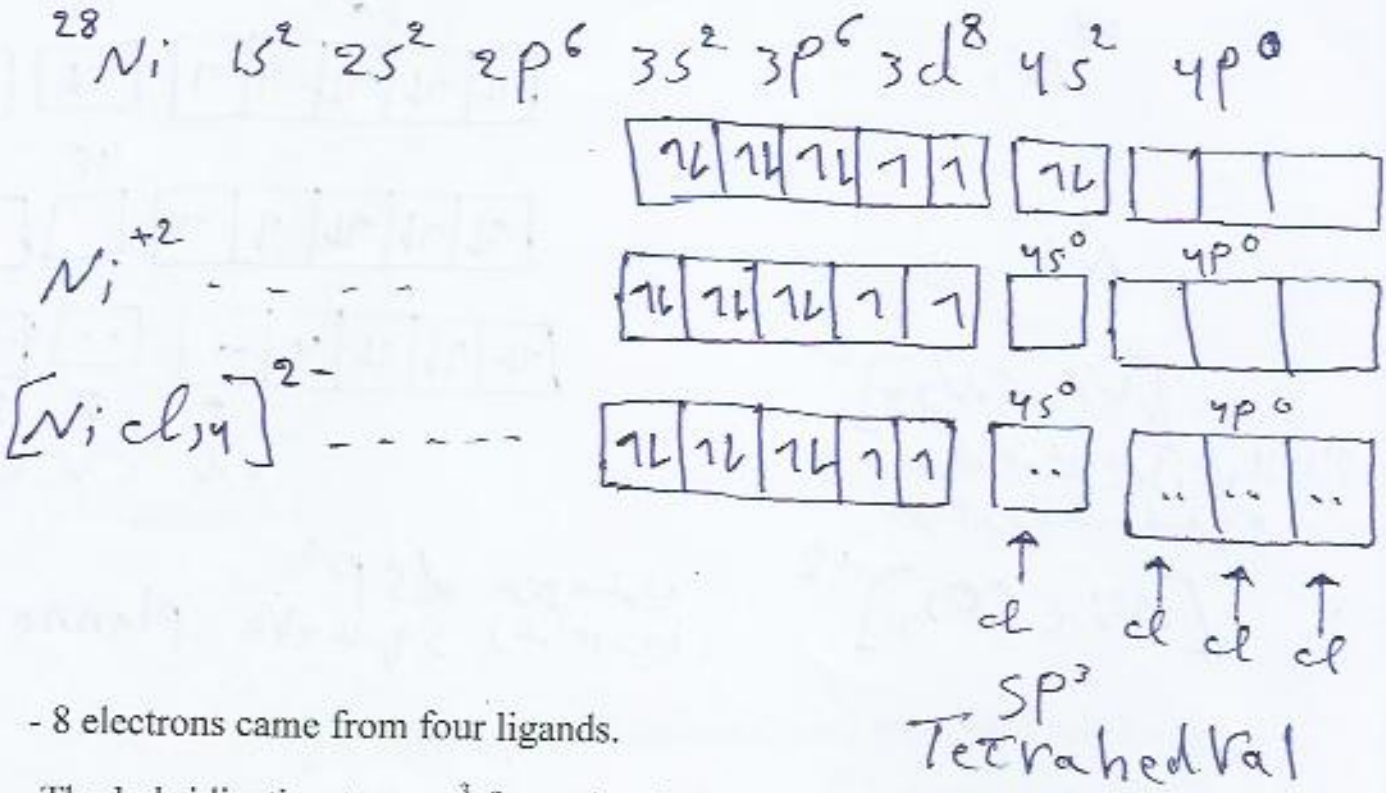
- Six electrons came from three ligands.

-The hybridization type sp^2 formation from orbital type s with two orbitals type p .

-Trigonal planner complex ion shape.

-The complex ion is a diamagnetic because of absence of a single electron in it.

Example 3: The complex ion of the nickel(II) tetrachloro $[NiCl_4]^{2-}$ the electronic structure of the outer shell of nickel and the electronic structure of the complex shall be as follows:



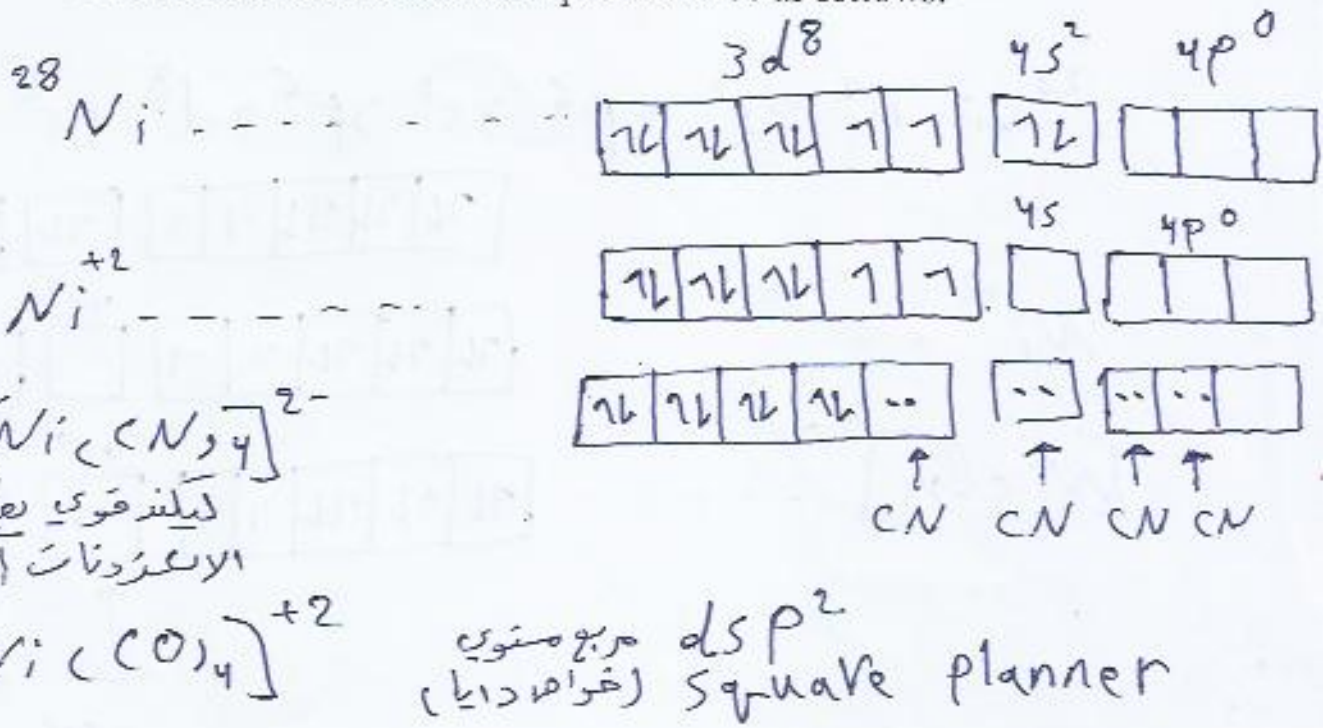
- 8 electrons came from four ligands.

-The hybridization type sp^3 formation from orbital type s with three orbitals type p .

-Tetrahedral complex ion shape.

-The complex ion is a paramagnetic because of presence pair electrons non paired .

Example 4: The complex ion of the nickel(II) tetracyanid $[NiCN_4]^{2-}$ the electronic structure of the outer shell of nickel and the electronic structure of the complex shall be as follows:



$[Ni(CN)_4]^{2-}$

ليكند قوي يعمل على ازدواج الالكترونات المنفرده

$[Ni(CO)_4]^{+2}$ مربع مستوي dsp^2 (خواص دايا) Squave planner

- 8 electrons came from four ligands.

-The hybridization type dsp^2 formation from orbital type d and one orbital from s with two orbitals type p .

-Square planer complex ion shape.

-The complex ion is a diamagnetic because of absence of a single electron in it .

مقدات المغناطيس

اذا كانت دايا مقناطيسيه = مربع مستوي ومقدات المغناطيس

بارا مقناطيسيه = رباعي السطوح

Note:

The single electrons of d remained as they were in the complex $[NiCl_4]^{2-}$ while they became double in the complex $[NiCN_4]^{2-}$ that is, the type of ligand has an important effect in this case where CN is a strong ligand because it makes single electrons In the complex that is formed paired. While the ion chlorine ligand is weak because it cannot make single electrons paired.

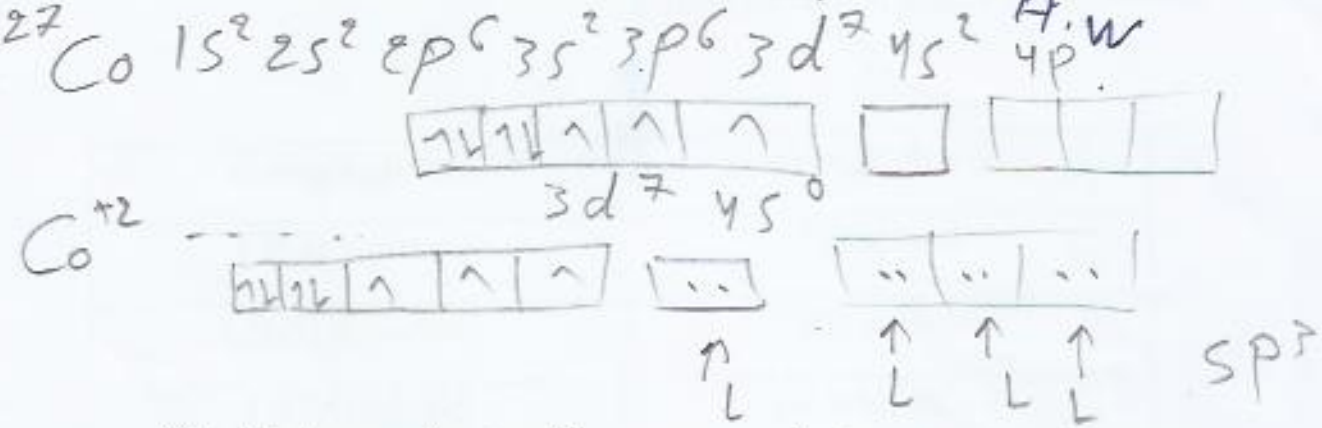
Weak ligands	Strong ligands
Iodide (I^-)	Cyanide (CN^-)
Bromide (Br^-)	Ammonia (NH_3)
Chloride (Cl^-)	Nitrite (NO_2^-)
Fluoride (F^-)	Carbonyl (CO)
Hydroxide (OH^-)	
Water (H_2O)	

Example:

Write the type of complex hybridization that contains cobalt where it represents $[CoL_4]^{2+}$ (The ligand hybridization is defined as L):

① اذا كان الليكند ضعيف

1 - The first case: The electronic structure of the outer shell of cobalt metal and electronic structure in the complex.



Note that according to this structure, single electrons are equal to 3 and hybrids of the type sp^3.

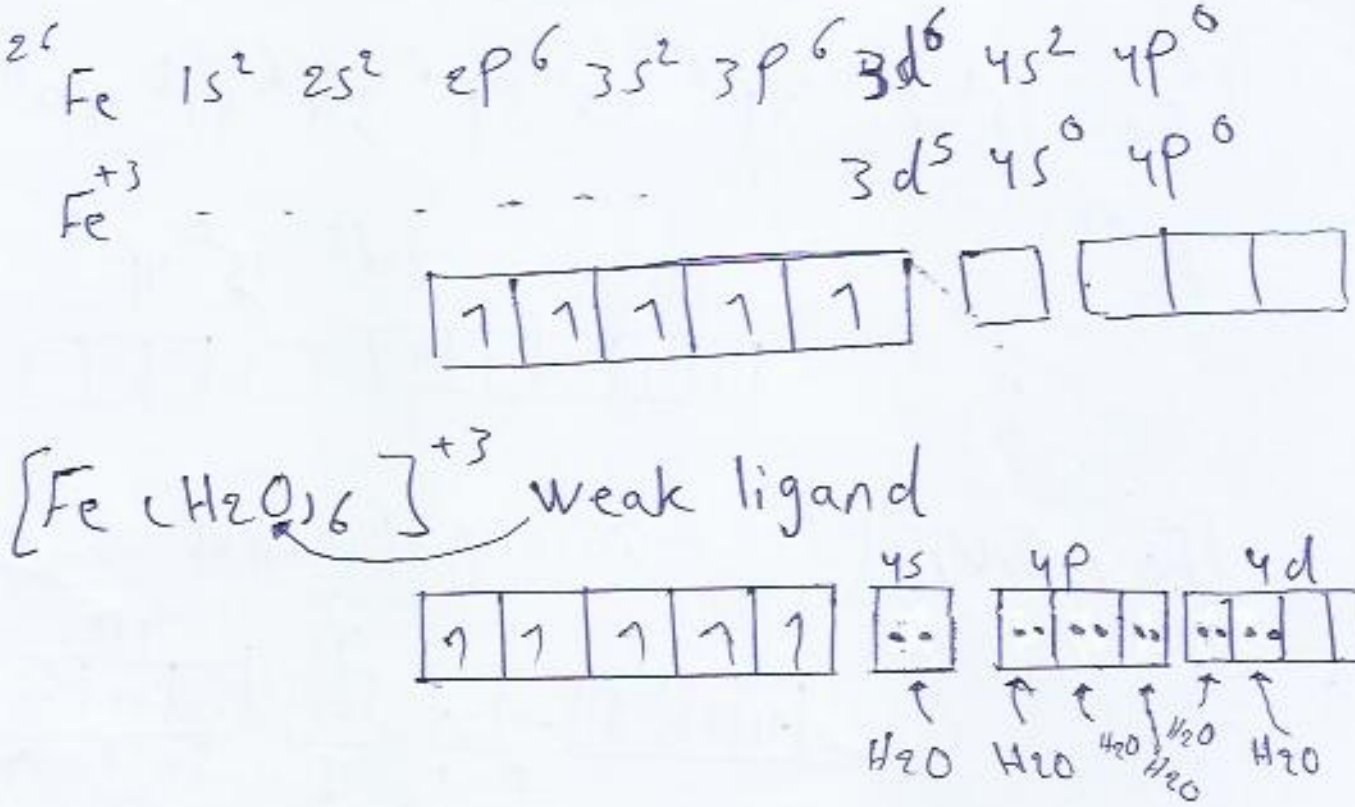
∴ الشكل الهندسي sp^3
رباعي السطوح (شكل الايون المعقد)

اذا كان الليكند قوي

2 - The second case: The electronic structure in the complex:

The number of single electrons equals one and the hybridization of a type dsp^2

Example: The complex ion of the iron (III) $[Fe(H_2O)_6]^{3+}$ the electronic structure of the outer shell of iron and the electronic structure of the complex shall be as follows:



sp^3d^2 النهجين من نوع

هذا العقد بسبب معقدات الاوربيتالات الخارجيه لانها تستخدم من اوربيتالات خارجيه للذرة المركزيه

- 12 electrons came from six ligands.

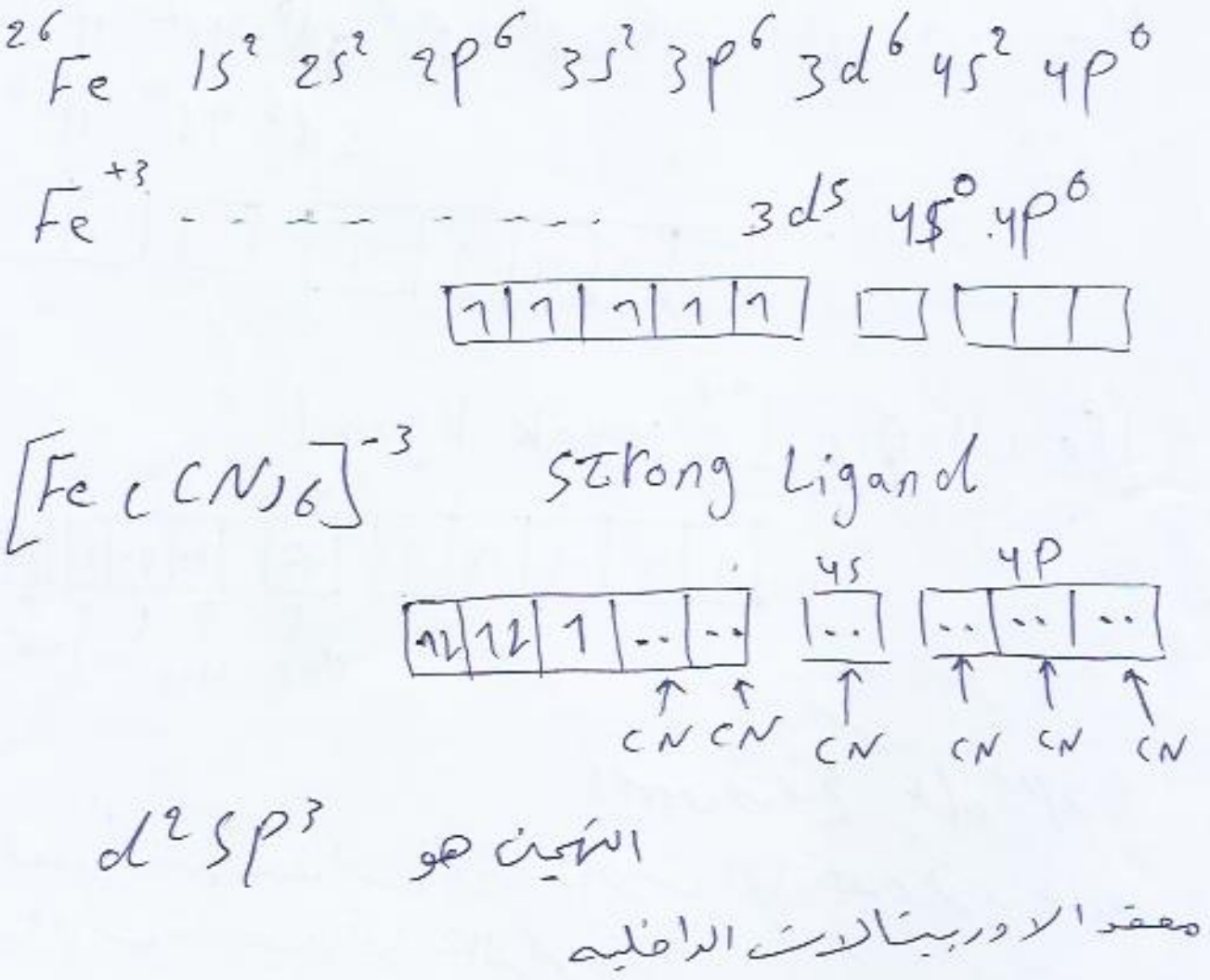
-The hybridization type sp^3d^2 formation from orbital type s and three orbital from p with two orbitals type d .

-Octahedral complex ion shape.

-The complex ion is a paramagnetic because of presence pair electrons non paired.

-Weak ligand.

Example: The complex ion of the iron (III) $[Fe(CN)_6]^{3-}$ the electronic structure of the outer shell of iron and the electronic structure of the complex shall be as follows:



d^2sp^3 التهجين هو

معقد الاوربيتالات الداخلية

- 12 electrons came from six ligands.

-The hybridization type d^2sp^3 formation from orbital type s and three orbital from p with two orbitals type d .

-Octahedral complex ion shape.

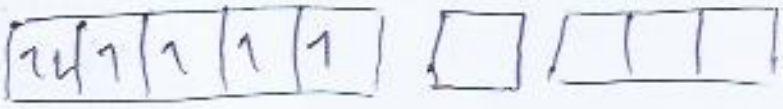
-The complex ion is a paramagnetic because of presence pair electrons non paired.

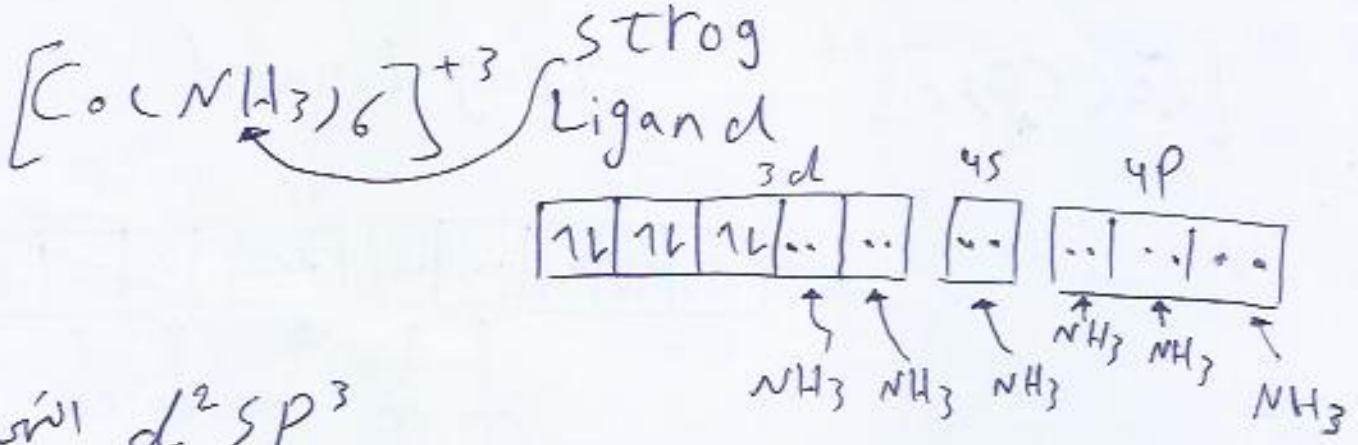
-Strong ligand.

Example: The complex ion of the cobalt (III) $[Co(NH_3)_6]^{3+}$ the electronic structure of the outer shell of iron and the electronic structure of the complex shall be as follows:

$^{27}Co \quad 1s^2 2s^2 2p^6 3s^2 3p^6 3d^7 4s^2 4p^6$

$Co^{+3} \quad - \; - \; - \; - \; - \; 3d^6 \; 4s^0 \; 4p$





التهجين هو d^2sp^3

هذا العقد بين مقعدات الاوربيتالات الداخلية لانها استخدمت اوربيتالات داخلية للذرة المركزية

- 12 electrons came from six ligands.

-The hybridization type d^2sp^3 formation from orbital type s and three orbital from p with two orbitals type d .

-Octahedral complex ion shape.

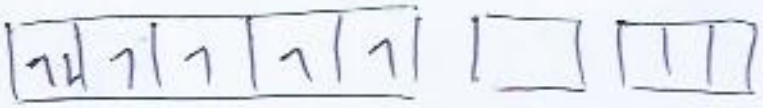
-The complex ion is a diamagnetic because of absence of a single electron in it .

-Strong ligand.

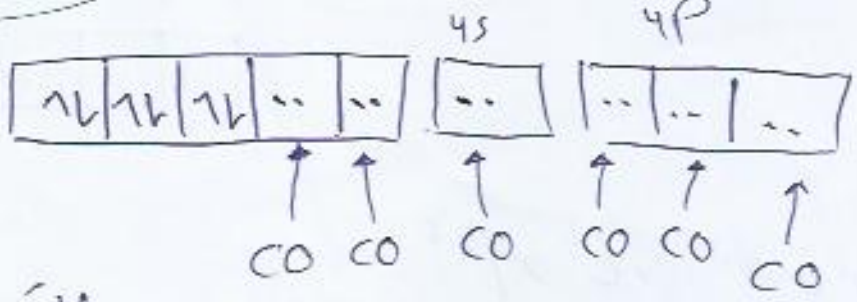
Example: The complex ion of the iron (II) $[Fe(CO)_6]^{2+}$ the electronic structure of the outer shell of iron and the electronic structure of the complex shall be as follows:

^{26}Fe $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 3d^6\ 4s^2\ 4p^0$

Fe^{+2} ... $3d^6\ 4s^0\ 4p^0$



$[Fe(CO)_6]^{+2}$ ... strong ligand



d^2sp^3 التهجين هو

معقد الاوربيتالات الداخلية

- 12 electrons came from six ligands.

-The hybridization type d^2sp^3 formation from orbital type s and three orbital from p with two orbitals type d .

-Octahedral complex ion shape.

-The complex ion is a diamagnetic because of absence of a single electron in it .

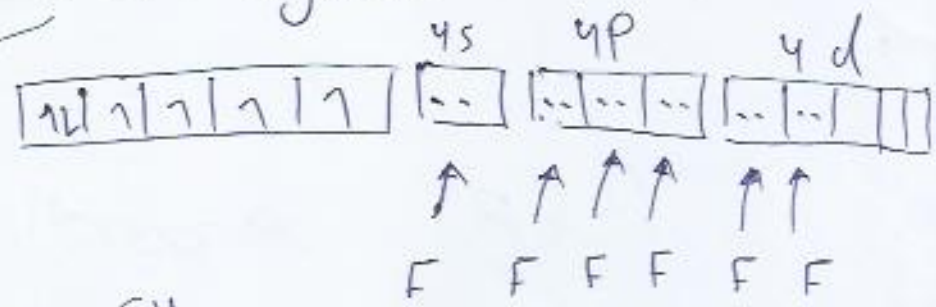
-Strong ligand.

Example: The complex ion of the cobalt (III) $[CoF_6]^{3-}$ the electronic structure of the outer shell of cobalt and the electronic structure of the complex shall be as follows:

$_{27}Co\ 1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 3d^7\ 4s^2\ 4p^0$

Co^{+3} - - - - - - $3d^6\ 4s^0\ 4p$

$[Co\overset{-1}{F}_6]^{-3}$ Weak ligand



sp^3d^2 التهجين من نوع

معقد الاوربيتالات الخارجية

- 12 electrons came from six ligands.

-The hybridization type sp^3d^2 formation from orbital type s and three orbital from p with two orbitals type d .

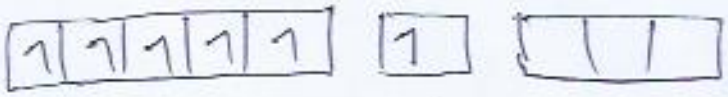
-Octahedral complex ion shape.

-The complex ion is a paramagnetic because of presence pair electrons non paired.

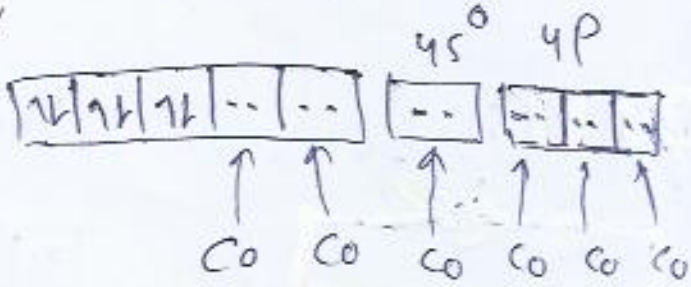
-Weak ligand.

Example: The complex ion of the chromium $[Cr(CO)_6]$ the electronic structure of the outer shell of chromium and the electronic structure of the complex shall be as follows:

$_{24}Cr \quad 1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 3d^5\ 4s^1\ 4p^0$



$[Cr(CO)_6]$ strong Ligand



d^2sp^3 التهجين هو

او مصفوفة الاوربيتالات الداخلية

$[Cr(NH_3)_6]$

- 12 electrons came from six ligands.

-The hybridization type d^2sp^3 formation from orbital type s and three orbital from p with two orbitals type d .

-Octahedral complex ion shape.

-The complex ion is a diamagnetic because of absence of a single electron in it .

-Strong ligand.