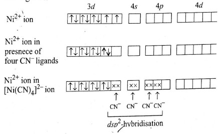
Square Planar Complexes

The square planar complexes involve dsp^2 or sp^2d hybridisation. X -C

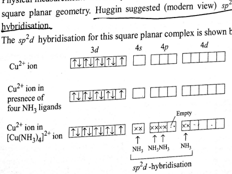
Example of Square Planar Complexes

(1) **$[Ni(CN)_4]^{2-}$ ion :** In this complex ion Ni (28) is present as Ni^{2+} ion. Ni atom has valence shell configuration $3d^8 4s^2$ and Ni^{2+} ion has valence shell configuration, $3d^8$. A free Ni^{2+} ion has eight $3d$-electrons, two of which are unpaired in accord with the Hund's rule. Magnetic measurements indicate that this complex ion is diamagnetic (no unpaired electron is present). In the presence of strong ligand (CN^-) all the electrons are paired up leaving one $3d$-orbital vacant. This vacant $3d$-orbital is hybridised with the $4s$ and tw of the $4p$ (p_x and p_y) orbitals to give the square planar dsp^2 hybrids. These four hybrids form bonds to the ligands by accepting lone pair of electrons from each of the four ligands.



(2) **$[Cu(NH_3)_4]^{2+}$ ion :** In this complex ion Cu (29) is present as Cu^{2+} ion. Cu atom has valence shell configuration. $3d^{10}4s^1$ and Cu^{2+} ion has valence shell configuration, $3d^9$. This complex ion may have either tetrahedral or square planar geometry. Magnetic measurements do not indicate whether the complex is tetrahedral or square planar as both the complexes have one unpaired electron. Physical measurements like X-rays difFeration and esr spectroscopy indicate that this complex have square planar geometry. Huggin suggested (modern view) sp^2d hybridisation rather than dsp^2 hybridisation.

The sp^2d hybridisation for this square planar complex is shown below:



Table

	Complex	Oxidation State	Configuration	Valence Bond Description	No of unpaired electrons
1.	$[V(H_2O)_6]^{3+}$	+3	$3d^2$	[↑][↑][ ][xx][xx] [xx] [xx][xx][xx]	2
2.	$[Cr(CN)_6]^{4-}$	+2	$3d^4$	[↑↓][↑][↑][xx][xx] [xx] [xx][xx][xx]	2
3.	$[Cr(NH_3)_6]^{++}$	+2	$3d^4$	[↑][↑][↑][↑][ ] [xx] [xx][xx][xx] [xx][xx][ ][ ][ ]	4
4.	$[Co(NO_2)_6]^{4-}$	+2	$3d^7$	[↑↓][↑↓][↑↓][xx][xx] [xx] [xx][xx][xx] [↑] 3d 4s 4p 5s	1
5.	$[Fe(CN)_5NO]^{--}$	+2	$3d^6$	[↑↓][↑↓][↑↓][xx][xx] [xx] [xx][xx][xx]	0
6.	$[PtF_6]^{--}$	+4	$5d^6$	[↑↓][↑↓][↑↓][xx][xx] [xx] [xx][xx][xx]	0
7.	$[Ni(NH_3)_6]^{++}$	+2	$3d^8$	[↑↓][↑↓][↑↓][↑][↑] [xx] [xx][xx][xx] [xx][xx][ ][ ][ ]	2
8.	$[Fe(H_2O)_5NO]^{++}$	+1	$3d^6 4s^1$	[↑↓][↑][↑][↑][↑] [xx] [xx][xx][xx] [xx][xx][ ][ ][ ]	0
9.	$[FeCl_4]^{--}$	+2	$3d^6$	[↑↓][↑][↑][↑][↑] [xx] [xx][xx][xx]	4
10.	$(Cu X4)^{--}$ $[X=Cl^-, Br^-, CNS^-]$	+2	$3d^9$	[↑↓][↑↓][↑↓][↑↓][↑] [xx] [xx][xx][xx]	1
11.	$[Cu(CN)_4]^{--}$	+2	$3d^9$	[↑↓][↑↓][↑↓][↑↓][↑] [xx] [xx][xx][ ] [xx][ ][ ][ ][ ] sp^2d-Hybridisation	1
12.	$[PtCl_4]^{--}$	+2	$5d^8$	[↑↓][↑↓][↑↓][↑↓][xx] [xx] [xx][xx][ ]	0

Shapes of *d*-Orbitals

Since *d* orbitals are often used in coordination complexes it is important to study their shapes distribution in space. The five *d* orbitals are not identical and the orbitals may be divided into two The three t_{2g} orbitals have identical shape and point between the axes, *x*, *y* and *z*. These *d*-orbitals d_{xy}, d_{yz} and d_{zx}. The two e_g orbitals have different shapes and point along the axes. These orbitals $d_{x^2-y^2}$ and d_{z^2}.