

Answer on Question #77892, Chemistry / Inorganic Chemistry

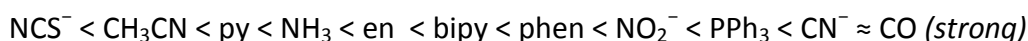
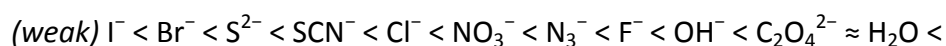
What are dsp^2 , d^2sp^3 and d^3s hybridizations? Why and how do they occur? Please give examples.

Solution

These types of hybridization (dsp^2 , d^2sp^3 , d^3s) can be seen in transition metal ions.

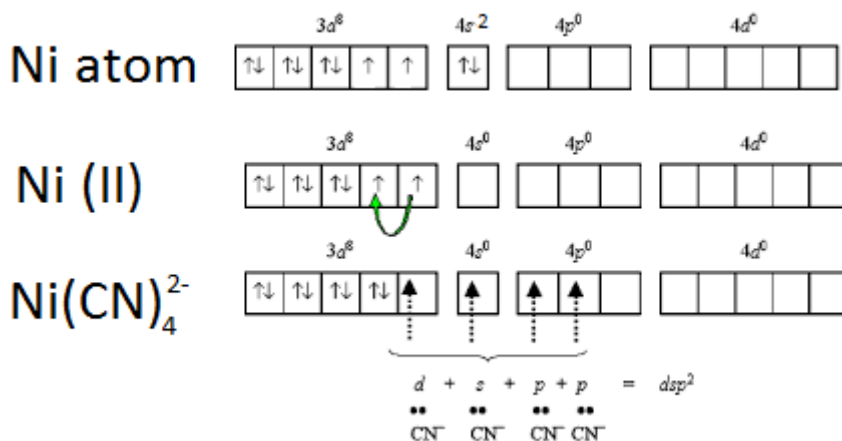
- 1) In dsp^2 hybridization one d orbital of the lower energy level, one s orbital and two p orbitals of the next energy level of a transition metal ion mix together to give four equivalent degenerate dsp^2 hybrid orbitals which are used to form bonds with ligands. These four orbitals lie in a plane with bond angles 90° with respect to each other (structure: square planar). Complexes with coordination number 4 can have tetrahedral or square planar structure. The choice depends on the strength of ligands. Strong field ligand lead to formation of square planar complexes whereas weak field ligands lead to formation of tetrahedral complexes.

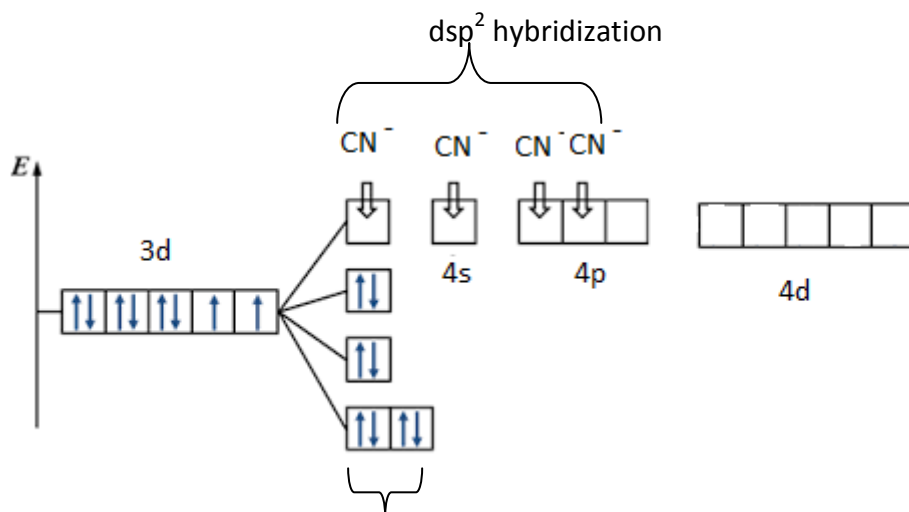
Spectrochemical series:



Strong field ligands repel the electrons of the d orbitals. As a result unpaired electrons of d orbitals get paired. Pairing of electrons creates empty d orbitals.

Examples: $[Ni(CN)_4]^{2-}$, $[Cu(NH_3)_4]^{2+}$





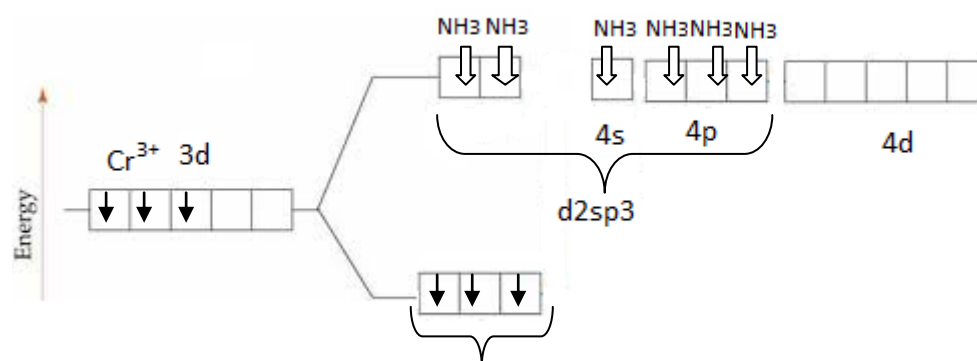
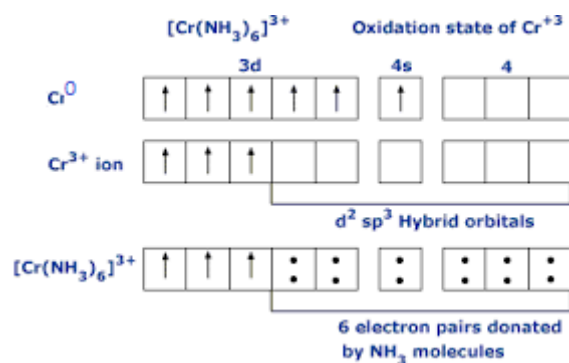
Splitting of d orbitals in square planar complex

- 2) In d²sp³ hybridization two d orbitals of lower energy level, one s orbital and three p orbitals of the next energy level of a transition metal ion mix together to give six equivalent degenerate d²sp³ hybrid orbitals which are used to form bonds with ligands. These six orbitals form octahedral structure with bond angles 90° with respect to each other.

Examples: [Fe(H₂O)₆]²⁺, CrF₆³⁻, [Fe(CN)₆]³⁻, [Co(C₂O₄)₃]³⁻

Empty d orbitals can be in a transition metal ion initially or can be formed in the strong field of the ligands due to the pairing.

For example, [Cr(NH₃)₆]³⁺



Splitting of d orbitals in octahedral complex

Note: sp^3d^2 hybridization formed of the one s, three p and two d orbitals of the SAME energy level.

- 3) In d^3s hybridization three d orbitals of lower energy level and one s orbital of the next energy level of a transition metal ion mix together to give four equivalent degenerate d^3s hybrid orbitals which are used to form bonds with ligands. These four orbitals form tetrahedral structure with bond angles 109.5° with respect to each other.

Examples: MnO_4^-

Mn configuration, $[Ar]4s^2 3d^5$

Mn^{+7} configuration, $[Ar]4s^0 3d^0 4p^0$

Tetrahedral structure can be achieved by two types of hybridization: sp^3 and d^3s . In case of Mn 3d AOs are lower than 4s and 4p AOs thus it achieves tetrahedral geometry by hybridization of d^3s . The oxygen atoms act as ligands to the manganese center and donate electrons to its $3d_{xy}$, d_{yz} , d_{zx} orbitals and to 4s orbital.

Answer provided by AssignmentExpert.com