L.S COLLEGE MUZAFFARPUR

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What are Inner Orbital Complexes

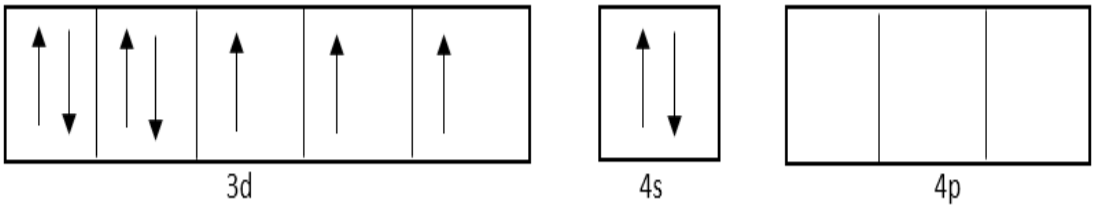
Inner orbital complexes are coordination compounds composed of a central metal atom having hybridization of the atomic orbitals including d orbitals of inner shell and s, p orbitals from the outer shell. In other words, the central metal atom of these complexes uses inner shell d orbitals for the hybridization of atomic orbitals. Therefore, these d orbitals are in a lower energy level than s and p orbitals.

The most common hybridization of the metal atom in inner orbital complexes is d^2sp^3. But there can be some other hybridizations as well, such as dsp^2. Let us consider an example in order to understand the formation of inner orbital complexes.

Example

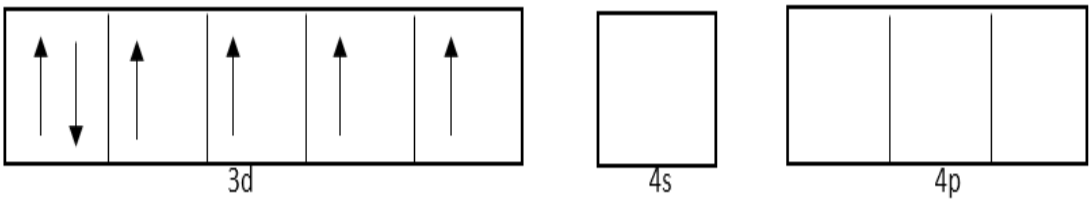
$[Co(NH_3)_6]^{+3}$ complex

The electron configuration of cobalt (Co) is $[Ar]3d^74s^2$.



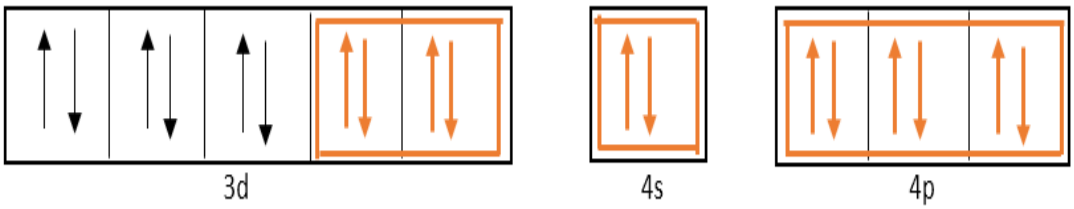
Since NH_3 ligands bear no electrical charges, the oxidation state of the Co atom should be +3.

The electron configuration of Co^{+3} is $[Ar]3d^6$.



In order to form 6 coordinate covalent bonds with the 6 ligands (NH_3), 6 atomic orbitals should be hybridized. Therefore, two of the 3d orbitals get hybridized with one 4s

orbital and three 4p orbitals.



Since the d orbitals that are involved in the hybridization are in electron shell 3 and the s and p orbitals are in the electron shell 4, the coordination complex formed with this metal atom is called an inner orbital complex. The arrows in orange color show the six lone electron pairs donated by the six ligands.

What are Outer Orbital Complexes

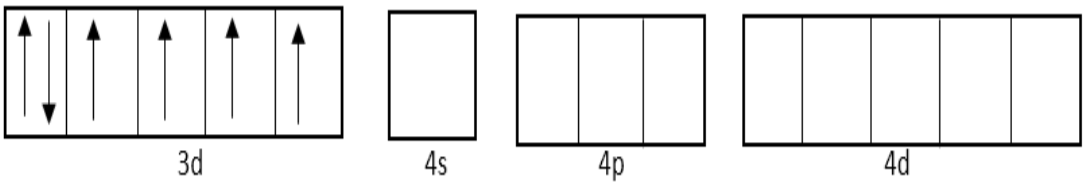
Outer orbital complexes are coordination compounds composed of a central metal atom having hybridization of the atomic orbitals including s, p and d orbitals from the outermost shell. Here, all atomic orbitals involved in the hybridization are in the same energy level. Since the d orbitals involved in this hybridization are located outside the s and p orbitals, the complexes formed from these metal atoms are called outer orbital complexes.

The most common hybridization that can be observed in this type of complexes is sp^3d^2. This can be explained using an example as shown below.

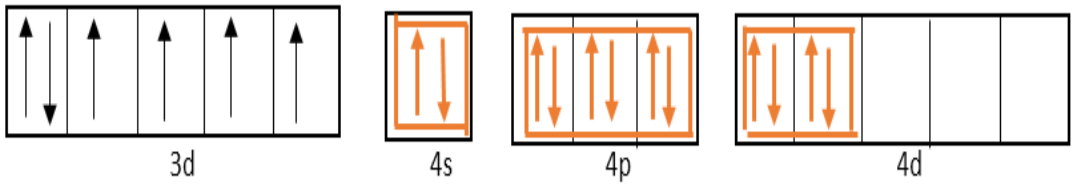
Example

$[CoF_6]^{-3}$ complex is a coordination complex.
The electron configuration of cobalt (Co) is $[Ar]3d^74s^2$.
The electrical charge of one F atom is -1. Therefore, the oxidation state of Co atom should be +3 in order to balance the overall charge of the complex.

The electron configuration of Co^{+3} is $[Ar]3d^6$.



In order to form coordinate covalent bonds, the 4s orbital, three 4p orbitals and two of the 4d orbitals are hybridized.



Since 4s, 4p and 4d orbitals are involved in hybridization, the lone electron pairs coming from Fluoride ions are filled to these hybrid orbitals. As d orbitals are located outside the s and p orbitals, the complexes formed from these metal atoms are called outer orbital complexes.

Difference Between Inner and Outer Orbital Complexes

Definition

Inner Orbital Complexes: Inner orbital complexes are coordinate compounds having a central metal atom that undergoes hybridization of atomic orbitals including the inner d orbitals.
Outer Orbital Complexes: Outer orbital complexes are coordinate compounds having a central metal atom that undergoes hybridization of atomic orbitals including outermost d orbitals.

Most Common Hybridization

Inner Orbital Complexes: The most common hybridization of metal atoms in inner orbital complexes is d^2sp^3.
Outer Orbital Complexes: The most common hybridization of metal atoms in outer orbital complexes is $sp^3\ d^2$.

Energy Levels

Inner Orbital Complexes: In inner orbital complexes, the d orbitals involved in the hybridization are in a lower energy level than s and p orbitals.
Outer Orbital Complexes: In Outer orbital complexes, the d orbitals involved in the hybridization are in the same energy level as the s and p orbitals.

Electron Shells

Inner Orbital Complexes: Inner orbital complexes are composed of metal atoms that use inner shell d orbitals for the hybridization in the central metal atom.

Outer Orbital Complexes: Outer orbital complexes are composed of metal atoms that use outermost shell d orbitals for the hybridization in the central metal atom.

Conclusion

Hybridization of atomic orbitals is a concept that is used in the Valence bond theory in order to describe the bonding between two atoms through the overlapping of their atomic orbitals. This theory can be used to explain the bonding in the coordination complexes. Here, according to the energy level of the d orbitals used in the hybridization of the central atom, the coordination complexes are in two types as inner orbital complexes and outer orbital complexes. The main difference between inner and outer orbital complexes is that the hybridization of the atomic orbitals of the central metal atom of inner orbital complex involves inner shell d orbitals whereas the hybridization of the atomic orbitals of the central metal atom of outer orbital complex involves outermost shell d orbitals.