Stereochemistry of Coordination compounds with different coordination numbers

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Stereochemistry of Coordination compounds

The ligands adopt a definite geometry around the central ion depending upon the coordination number of the ion. The arrangement of the coordinated ligands is such that the electrostatic repulsion between them is minimum. The stereochemistry of the complexes with coordination numbers varying from 2 to 9.

Coordination Number 2

Two arrangements are possible for compounds with coordination number 2: i) Linear ii) Bent

When the central ion utilizes the two hybrid orbitals for bonding with the ligands and does not contain any lone pair of electrons, it forms linear complexes.

when the central ion utilizes, apart from the two hybrid orbitals, one or more additional hybrid orbitals for accommodating lone pairs of electrons, it forms bent complexes.

Ex:

$[CuCl_2]^-$, $[Au(CN)_2]^-$, $[Ag(NH_3)_2]^+$

Coordination Number 3

This coordination number is uncommon, rather rare. Several compounds which from their stereochemistry appear to be 3-coordinate, are found upon examination to have higher coordination numbers.

Ex:

$K[Cu(CN)_2]$

Coordination Number 4

The two principal geometries encountered are

i) Tetrahedral

ii) Square planar

Tetrahedral geometry

This geometry is complexes of transition as well as non-transition elements.

Ex:

$[BeF_4]^{2-}$, $[BF_4]^{-}$, $[ZnCl_4]^{2-}$, $[Cd(CN)_4]^{2-}$, $[MnCl_4]^{2-}$

Square planar geometry

This geometry is complexes of transition elements only.

Ex:

$[PtCl_4]^{2-}$, $[Ni(CN)_4]^{2-}$, $[Cu(NH_3)_4]^{2-}$, $[PdCl_4]^{2-}$

Coordination Number 5

Complexes with coordination number 5, with coordination number 3, are rather rare. Complexes in which the metal ion was considered to be having coordination number 5 to have the metal ion with different coordination number.

Ex:

$(NH_4)_3[ZnCl_5]$ in which the complex ion $[ZnCl_5]^{3-}$

Two principal geometries in the compounds in which this coordination number 5 has been established are

i) Trigonal Bipyramidal

ii) Square Pyramidal

Trigonal bipyramidal geometry:

$[Fe(CO)_5]$, $[MoCl_5]^-$, $[CuCl_5]^{3-}$, $[SnCl_5]^-$

Square bipyramidal geometry:

$[SbF_5]^{2-}$, $[VO(acac)_2]$ and $[Ni\{(C_6H_5)P\}_2Br_3]^-$

Coordination Number 6

The regular geometric arrangement is octrahedral due to distortions the geometry changes to tetragonal.

Ex:

$[Cu(NH_3)_6]^{2+}$, $[FeF_6]^{3-}$, $[TiF_6]^{2-}$, $[PtF_6]^{4-}$ and $[SbF_6]^{-}$

Coordination Number 7

Three geometrical forms are as follows:

i) Pentagonal bipyramidal

$[UO_2F_5]^{3-}$, $[UF_7]^{3-}$ and $[ZrF_7]^{3-}$

ii) Distorted octahedrom

$[NbOF_6]^{3-}$

iii) Trigonal prism

$[NbF_7]^{2-}$ and $[TaF_7]^{2-}$

Coordination Number 8

Three types of geometries of compounds are

i) Cubic

ii) Square Antiprism

iii) Doedecahedral

Cubic geometry: The most symmetrical arrangement is simple cubic. Ex: $[UF_8]^{3-}$

Square antiprism geometry: This depicts a distortion in the cubic geometry which is adopted to minimise the repulsion between the anions. Ex: $[TaF_8]^{3-}$, $[ReF_8]^{2-}$ and $[Zr(acac)_4]$

Doedecahedral geometry: $[Mo(CN)_8]^{4-}$ and $[Zr(ox)_4]^{4-}$

Coordination Number 9

There is only one symmetrical arrangement known for this coordination number. This is derived from a trigonal prism by placing the three additional atoms outside the centres of the three vertical faces.

Ex:

$[Nd(BrO_3)_3].9H_2O$ which contains $[Nd(H_2O)_9]^{3+}$ as the complex ion in which the central ion Nd^{3+} has coordination number 9.