

Stability of co-ordination in solution and Spectrochemical series.

Stronger is the metal-ligand bond, less is the dissociation in the solution and hence greater is the stability of a coordination compounds.

Instability constant for the complex ion $[Cu(NH_3)_4]^{2+}$ i.e.

$$[Cu(NH_3)_4]^{2+} \rightleftharpoons Cu^{2+} + 4 NH_3, \text{ is given by the expression; } K_i = \frac{[Cu^{2+}][NH_3]^4}{[Cu(NH_3)_4]^{2+}}.$$

Stability constant of the above complex i.e.

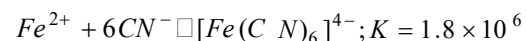
$$Cu^{2+} + 4 NH_3 \rightleftharpoons [Cu(NH_3)_4]^{2+} \text{ is given as under ; } K = \frac{[Cu(NH_3)_4]^{2+}}{[Cu^{2+}][NH_3]^4} = \frac{1}{K_i},$$

Greater is the stability constant, stronger is the metal – ligand bond

Factors affecting the stability of complex ion

(1) **Nature of central metal ion** : The higher the charge density on the central metal ion the greater is the stability of the complex

For example, the stability constant of $[Fe(CN)_6]^{3-}$ is much greater than the stability constant of $[Fe(CM)_6]^{4-}$.



Effective atomic number (EAN) or Sidgwick theory : In order to the stability of the complexes sidgwick proposed effective atomic number. EAN generally coincides with the atomic number of next noble gas in some cases. EAN is calculated by the following relation :

$EAN = \text{Atomic no. of the metal} - e^- \text{ lost in ion formation} + \text{No. of } e^- \text{ gained from the donor atom of the ligands.}$

$EAN = \text{Atomic number} - \text{Oxidation number} + \text{co-ordination no.} \times 2$

Complex	Metal oxidation state	At. No. of metal	Coordination number	Effective atomic number
$K_4[Fe(CN)_6]$	+ 2	26	6	$(26 - 2) + (6 \times 2) = 36$ [Kr]
$[Cu(NH_3)_4]SO_4$	+ 2	29	4	$(29 - 2) + (4 \times 2) = 35$

$[\text{Co}(\text{CH}_3)_6]\text{Cl}_3$	+ 3	27	6	$(27 - 3) + (6 \times 2) = 36$ [Kr]
$\text{Ni}(\text{CO})_4$	0	28	4	$(28 - 0) + (4 \times 2) = 36$ [Kr]
$\text{K}_2[\text{Ni}(\text{CN})_4]$	+ 2	28	4	$(28 - 2) + (4 \times 2) = 34$
$\text{K}_2[\text{PtCl}_6]$	+ 4	78	6	$(78 - 4) + (6 \times 2) = 86$ [Rn]
$\text{K}_3[\text{Cr}(\text{C}_2\text{O}_4)_3]$	+ 3	24	6	$(24 - 3) + (6 \times 2) = 33$
$\text{K}_3[\text{Fe}(\text{CN})_6]$	+ 3	26	6	$(26 - 3) + (6 \times 2) = 35$
$\text{K}_2[\text{HgI}_4]$	+ 2	80	4	$(80 - 2) + (4 \times 2) = 86$ [Rn]
$[\text{Ag}(\text{NH}_3)_2]\text{Cl}$	+ 1	47	2	$(47 - 1) + (2 \times 2) = 50$
$\text{K}_2[\text{PdCl}_4]$	+ 2	46	4	$(46 - 2) + (4 \times 2) = 52$

(2) **Nature of ligand:** Greater the base strength is the ease with which it can donate its lone pair of electrons and therefore, greater is the stability of the complex formed by it.

For example : $[\text{Cu}(\text{NH}_3)_4]^{2+}; K = 4.5 \times 10^{11}$; $[\text{Cu}(\text{CN})_4]^{2-}; K = 2.0 \times 10^{27}$

(3) **Presence of chelate ring:** Chelating ligands form more stable complex as compared to monodentate ligands. For example : $\text{Ni}^{2+} + 6\text{NH}_3 \rightleftharpoons [\text{Ni}(\text{NH}_3)_6]^{2+}; K = 6 \times 10^8$; $\text{Ni}^{2+} + 3\text{en} \rightleftharpoons [\text{Ni}(\text{en})_3]^{2+}; K = 4 \times 10^8$

Spectro chemical series .Ligands can be arranged in increasing order of their strength (ability to cause crystal field splitting) and the series so obtained is called as spectro chemical series.

$\text{I}^- < \text{Br}^- < \text{Cl}^- < \text{F}^- < \text{OH}^- < \text{OX}^{2-} < \text{H}_2\text{O} < \text{Py} < \text{NH}_3 < \text{en} < \text{NO}_2^- < \text{CN}^- < \text{CO}$.

Ligands arranged left to NH_3 are generally regarded as weaker ligands which can not cause forcible pairing of electrons within 3d level and thus form outer orbital octahedral complexes. On the other hand NH_3 and all ligands lying right to it are stronger ligands which form inner orbital octahedral complexes after forcible pairing of electrons within 3d level.