Overall formation of complex ML_n

Now the formation of the complex ML_n may be expressed by the following steps and equilibrium constants -

$$M + L \overset{\beta_1}{\rightleftharpoons} ML, \quad \therefore \beta_1 = \frac{[ML]}{[M][L]}$$

$$M + 2L \overset{\beta_2}{\rightleftharpoons} ML_2 \quad \therefore \beta_2 = \frac{[ML_2]}{[M][L]^2}$$

$$M + 3L \overset{\beta_3}{\rightleftharpoons} ML_3, \quad \therefore \beta_3 = \frac{[ML_3]}{[M][L]^3}$$

$$M + 4L \overset{\beta_4}{\rightleftharpoons} ML_4 \quad \therefore \beta_4 = \frac{[ML_4]}{[M][L]^4}$$

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$$M + nL \overset{\beta_n}{\rightleftharpoons} ML_n \quad \therefore \beta_n = \frac{[ML_n]}{[M][L]^n}$$

The Equilibrium Constants, $\beta_1, \beta_2, \beta_3, \beta_4 \ldots\ldots \beta_n$ are called Overall or Cumulative formation Constant. or, Overall or Cumulative Stability Constant.

The Value of Stability constant regularly decrease from K_1 to K_4. It's illustrated by the following data.

$$Cd^{2+} + NH_3 \underset{}{\overset{K_1}{\rightleftharpoons}} [Cd(NH_3)]^{2+}, \quad K_1 = 10^{2.25}$$

$$[Cd(NH_3)]^{2+} + NH_3 \overset{K_2}{\rightleftharpoons} [Cd(NH_3)_2]^{2+}, \quad K_2 = 10^{2.10}$$

$$[Cd(NH_3)_2]^{2+} + NH_3 \overset{K_3}{\rightleftharpoons} [Cd(NH_3)_3]^{2+}, \quad K_3 = 10^{1.44}$$

$$[Cd(NH_3)_3]^{2+} + NH_3 \overset{K_4}{\rightleftharpoons} [Cd(NH_3)_4]^{2+}, \quad K_4 = 10^{0.95}$$

But value $\beta_4 = 10^{7.12}$

b) When the Ligands are Charged Molecules: —

$$Cd^{2+} + CN^- \overset{K_1}{\rightleftharpoons} [Cd(CN)]^+, \quad K_1 = 10^{5.48}$$

$$[Cd(CN)]^+ + CN^- \overset{K_2}{\rightleftharpoons} [Cd(CN)_2], \quad K_2 = 10^{5.12}$$

$$[Cd(CN)_2] + CN^- \overset{K_3}{\rightleftharpoons} [Cd(CN)_3]^-, \quad K_3 = 10^{4.63}$$

$$[Cd(CN)_3]^- + CN^- \overset{K_4}{\rightleftharpoons} [Cd(CN)_4]^{2-}, \quad K_4 = 10^{3.65}$$

but, $\beta_4 = 10^{18.8}$

The steady decrease in the Value of $K_1, K_2 \cdots K_n$ with increasing number of Ligands is due to the fact that as more and more Ligands moves into the Co-ordination Zone, then less and less aqua - molecules are available to fresh Ligands for replacement. As the number of ligands increases the metal ion becomes less greedy in the complex containing charged Ligands, the important factor which is responsible for the steady decrease are Statistical, Steric hindrance and Coulombic factors.

The step wise stability Constant is also expressed as $\log_{10} K_1$, $\log_{10} K_2$ ---- $\log_{10} K_n$ and $\log_{10} \beta_n$ respectively.