Lewis Acids and Bases

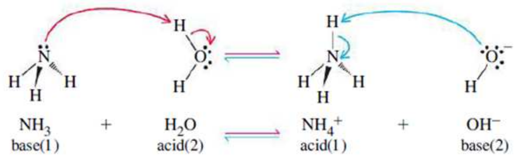
According to **Bronsted-Lowry:** acid is a proton donor
base is a proton acceptor

$$\underset{\text{Base}}{NH_3} + \underset{\text{Acid}}{H_2O} \longrightarrow NH_4^+ + OH^-$$

Rewriting Bronsted-Lowry: acid is compound having protons. The proton can share a pair of electrons of a base

base is compound having a pair of electrons willing to share them with a proton

an acid-base reaction is the transfer of a proton

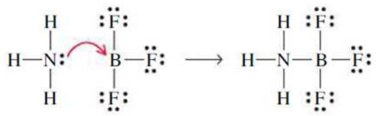


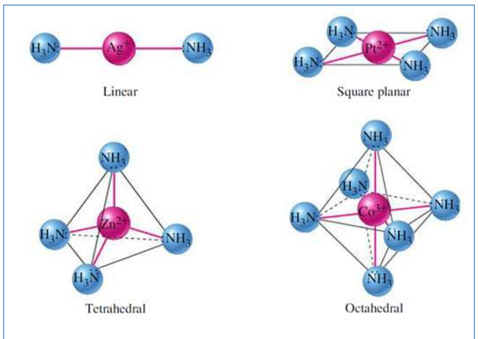
Lewis claim: There are other acids than protons!

According to **Lewis**:

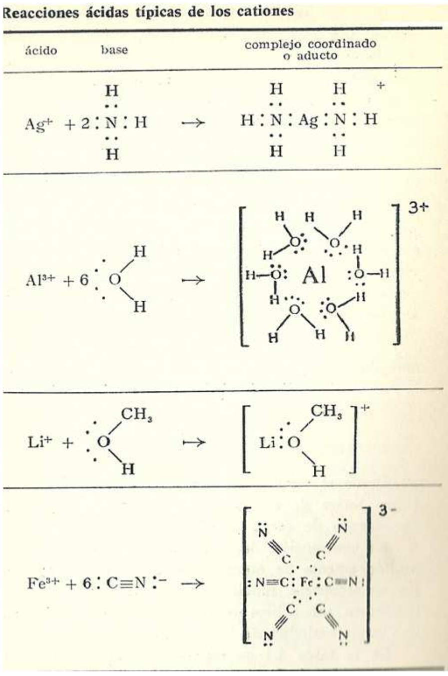
acid is compound having an atom willing to share a pair of electrons of a base
base is compound having a pair of electrons willing to share them with an acid

an acid-base reaction is the sharing of a pair of electrons





Structures of some complex ions

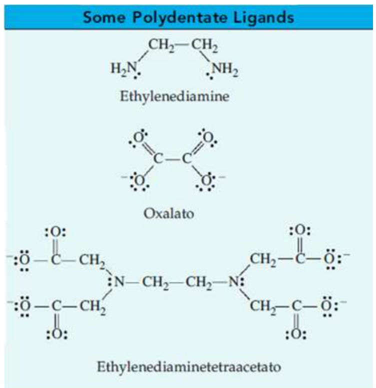


Complex equilibrium notation :

M (acceptor) + n L (donor) ⇄ ML_n (complex)
Lewis acid Lewis base complex

Ligands:

Monodentate: H_2O, NH_3, CO, NO …
Polydentate:



Chelate: a class of complex compounds consisting of a central metal atom attached to a large molecule (ligand) in a cyclic or ring-like structure.

$$\begin{matrix} ^{-}OOC-CH_2 & & CH_2-COO^{-} \\ & N-CH_2-CH_2-N & \\ ^{-}OOC-CH_2 & & CH_2-COO^{-} \end{matrix}$$

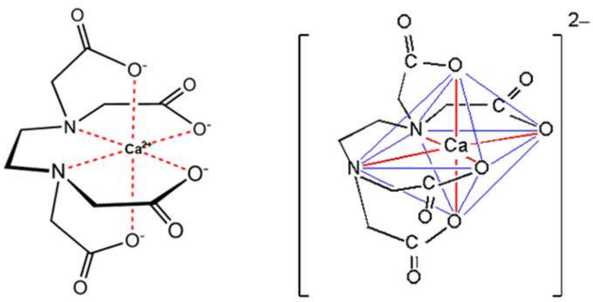


TABLE 18.2 Formation Constants for Some Complex Ions[a]

Complex Ion	Equilibrium Reaction[b]	K_f
$[Co(NH_3)_6]^{3+}$	$Co^{3+} + 6\,NH_3 \rightleftharpoons [Co(NH_3)_6]^{3+}$	4.5×10^{33}
$[Cu(NH_3)_4]^{2+}$	$Cu^{2+} + 4\,NH_3 \rightleftharpoons [Cu(NH_3)_4]^{2+}$	1.1×10^{13}
$[Fe(CN)_6]^{4-}$	$Fe^{2+} + 6\,CN^- \rightleftharpoons [Fe(CN)_6]^{4-}$	1×10^{37}
$[Fe(CN)_6]^{3-}$	$Fe^{3+} + 6\,CN^- \rightleftharpoons [Fe(CN)_6]^{3-}$	1×10^{42}
$[Pb(OH)_3]^-$	$Pb^{2+} + 3\,OH^- \rightleftharpoons [Pb(OH)_3]^-$	3.8×10^{14}
$[PbCl_3]^-$	$Pb^{2+} + 3\,Cl^- \rightleftharpoons [PbCl_3]^-$	2.4×10^{1}
$[Ag(NH_3)_2]^+$	$Ag^+ + 2\,NH_3 \rightleftharpoons [Ag(NH_3)_2]^+$	1.6×10^{7}
$[Ag(CN)_2]^-$	$Ag^+ + 2\,CN^- \rightleftharpoons [Ag(CN)_2]^-$	5.6×10^{18}
$[Ag(S_2O_3)_2]^{3-}$	$Ag^+ + 2\,S_2O_3^{2-} \rightleftharpoons [Ag(S_2O_3)_2]^{3-}$	1.7×10^{13}
$[Zn(NH_3)_4]^{2+}$	$Zn^{2+} + 4\,NH_3 \rightleftharpoons [Zn(NH_3)_4]^{2+}$	4.1×10^{8}
$[Zn(CN)_4]^{2-}$	$Zn^{2+} + 4\,CN^- \rightleftharpoons [Zn(CN)_4]^{2-}$	1×10^{18}
$[Zn(OH)_4]^{2-}$	$Zn^{2+} + 4\,OH^- \rightleftharpoons [Zn(OH)_4]^{2-}$	4.6×10^{17}

Cumulative formation constants

$$\beta_1 = K_1 = \frac{[ML]}{[M][L]} \qquad \beta_2 = K_1K_2 = \frac{[ML]}{[M][L]} \cdot \frac{[ML_2]}{[ML][L]} = \frac{[ML_2]}{[M][L]^2}$$

$$\beta_3 = K_1K_2K_3 = \frac{[ML_3]}{[M][L]^3} \qquad \beta_n = K_1K_2K_3 \ldots K_n = \frac{[ML_n]}{[M][L]^n}$$

$$[ML_n] = \beta_n [M][L]^n$$

m=[M]

l =[L]

$$c_M = [M] + [ML] + [ML_2] + \ldots + [ML_n] = m\left(1 + \beta_1 l + \beta_2 l^2 + \beta_3 l^3 + \ldots + \beta_n l^n\right)$$

$$m = \frac{1}{1 + \beta_1 l + \beta_2 l^2 + \beta_3 l^3 + \ldots + \beta_n l^n} c_M$$