Introduction to Hard–Soft Acid–Base Theory

Many metal ions form metal-ligand complexes with halide ions, for which we can write the following general reaction

$$M^{n+}(aq) + X^{-}(aq) \leftrightarrows MX^{(n-1)+}(aq)$$

The equilibrium constant for this reaction is called a metal-ligand formation constant, K_f, and the larger its value, the more favorable the formation of the metal-ligand complex. The table below provides values of K_f for indium(III) and for mercury(II).

metal ion	F^-	Cl^-	Br^-	I^-
In^{3+}	39,800	208	110	43.7
Hg^{2+}	31.6	23,400	4.57×10^{9}	3.16×10^{13}

The relative affinity of halides for metal ions also can be examined by looking at solubility data. The table below, for example, compares the solubility, in mol/L, of sodium halides, NaX*(s)*, and silver halides, AgX*(s)*.

metal ion	F^-	Cl^-	Br^-	I^-
Na^+	1.0	6.1	11.3	12.3
Ag^+	14.3	1.3×10^{-6}	7.2×10^{-7}	9.1×10^{-9}

This is interesting data. What do you make of this data? What patterns do you see in this data? What questions do this data raise for you? You may wish to consider data on the melting points of these compounds (all values in °C).

metal ion	F^-	Cl^-	Br^-	I^-
Na^+	993	801	747	661
Ag^+	435	455	430	558
In^{3+}	1172	586	420	—
Hg^{2+}	645	276	237	259