Acid Equilibria

\[
\ce{SO42-(aq) + H2O(l) <=> HSO4-(aq) + OH-(aq)}
\]
with \( K_b = 1 \times 10^{-12} \)

\[
\ce{HSO4-(aq) + H2O(l) <=> H2SO4(aq) + OH-(aq)}
\]
with \( K_b = 1 \times 10^{-15} \)

Sulfate ion is a very weak base, while \( \ce{HSO4^-} \) is a fairly strong acid, with \( K_a = 0.01 \). On the other hand, \( \ce{H2SO4} \) is a very strong acid. Because it is such a weak base, sulfate ion undergoes negligible hydrolysis in aqueous solution.

Solubility

Most sulfates, including those of \( \ce{Na^+} \), \( \ce{K^+} \), and \( \ce{NH4^+} \), are soluble in water. Exceptions that are insoluble are white lead(II) sulfate and white barium sulfate:

\[
\ce{BaSO4(s) <=> Ba2+(aq) + SO42-(aq)}
\]
with \( K_{sp} = 1.4 \times 10^{-8} \)

\[
\ce{PbSO4(s) <=> Pb2+(aq) + SO42-(aq)}
\]
with \( K_{sp} = 1.1 \times 10^{-10} \)

Formation of white \( \ce{BaSO4} \) upon addition of \( \ce{Ba^{2+}} \) to a solution of \( \ce{SO4^{2-}} \), even if it is acidic, is a reliable test for sulfate. Other insoluble sulfates are those of calcium, strontium, and mercury(I).

Oxidation-Reduction:

Sulfate is a very weak oxidizing agent. Since sulfur is in its maximum oxidation number in sulfate ion, this ion cannot act as a reducing agent.