Marks 5

- Nickel metal can be extracted and recycled from mobile phone batteries. This process leads to solutions containing both $Cu^{2+}(aq)$ and $Ni^{2+}(aq)$ ions. Separation of these ions is achieved by adding tiny amounts of sulfide ions as the metal sulfides have low and very different solubilities: $K_{sp}(CuS) = 8 \times 10^{-34}$ and $K_{sp}(NiS) = 3 \times 10^{-19}$.

  An aqueous solution has $[Ni^{2+}(aq)] = 0.0100$ M and an unknown concentration of $Cu^{2+}(aq)$ ions. $S^{2-}(aq)$ ions are added in small increments. CuS begins to precipitate when $[S^{2-}(aq)] = 8 \times 10^{-32}$ M. What was the original value of $[Cu^{2+}(aq)]$?

The solubility of CuS is *much* lower than NiS as its K_{sp} value is *much* smaller. When CuS begins to precipitate, virtually none will be left in solution.

CuS(s) dissolves to give $Cu^{2+}(aq)$ and $S^{2-}(aq)$, so K_{sp} (CuS) = $[Cu^{2+}(aq)][S^{2-}(aq)]$.

As $K_{sp} = 8 \times 10^{-34}$ and precipitation occurs when $[S^{2-}(aq)] = 8 \times 10^{-32}$ M,

$[Cu^{2+}(aq)] = K_{sp}(CuS) / [S^{2-}(aq)] = (8 \times 10^{-34}) / (8 \times 10^{-32}) = 0.01$ M

Answer: **0.01 M**

At what $[S^{2-}(aq)]$ will NiS precipitate?

NiS(s) dissolves to give $Ni^{2+}(aq)$ and $S^{2-}(aq)$, so $K_{sp}(NiS) = [Ni^{2+}(aq)][S^{2-}(aq)]$.

As $K_{sp} = 3 \times 10^{-19}$ and $[Ni^{2+}(aq)] = 0.0100$ M,

$[S^{2-}(aq)] = K_{sp}(NiS) / [Ni^{2-}(aq)] = (3 \times 10^{-19}) / (0.0100) = 3 \times 10^{-17}$ M

Answer: **3×10^{-17} M**

If the CuS formed is filtered off before any NiS precipitates, how pure will the NiS precipitate be?

From above, NiS precipitates when $[S^{2-}(aq)] = 3 \times 10^{-17}$ M. At this concentration,

$[Cu^{2+}(aq)] = K_{sp}(CuS) / [S^{2-}(aq)] = (8 \times 10^{-34}) / (3 \times 10^{-17}) = 3 \times 10^{-17}$ M

When NiS starts to precipitate, $[Ni^{2+}(aq)] = 0.0100$ M and $[Cu^{2+}(aq)] = 3 \times 10^{-17}$ M.

The NiS that precipitates will contain *very* little Cu^{2+}: it will be *very* pure.

Answer: **100%**