Marks 8

- A solution is prepared that contains sodium chloride and sodium chromate (both 0.10 M). When a concentrated solution of silver nitrate is added slowly, white AgCl(s) begins to precipitate. After most of the Cl^-(aq) has been consumed, red Ag_2CrO_4(s) starts to precipitate.

  Ignoring dilution, what is the concentration of silver ions when silver chloride solid first starts to precipitate? K_{sp} (AgCl) is 1.8×10^{-10}.

K_{sp} refers to the dissolution reaction: $AgCl(s) \rightleftharpoons Ag^+(aq) + Cl^-(aq)$

$K_{sp}(AgCl) = [Ag^+(aq)][Cl^-(aq)]$

As $[Cl^-(aq)] = 0.10$ M, the minimum concentration of $Ag^+(aq)$ required to ensure AgCl(s) is present is given by:

$[Ag^+(aq)] = K_{sp}(AgCl) / [Cl^-(aq)] = (1.8 \times 10^{-10} / 0.10)$ M $= 1.8 \times 10^{-9}$ M

Answer: **1.8×10^{-9} M**

Ignoring dilution, what is the concentration of silver ions when silver chromate solid first starts to precipitate? K_{sp} (Ag_2CrO_4) is 3.6×10^{-12}.

K_{sp} refers to the dissolution reaction: $Ag_2CrO_4(s) \rightleftharpoons 2Ag^+(aq) + CrO_4^-(aq)$

$K_{sp}(Ag_2CrO_4) = [Ag^+(aq)]^2[CrO_4^-(aq)]$

As $[CrO_4^-(aq)] = 0.10$ M, precipitation of $Ag_2CrO_4(s)$ will occur when:

$[Ag^+(aq)]^2 = K_{sp}(Ag_2CrO_4) / [CrO_4^-] = (3.6 \times 10^{-12} / 0.10)$ M $= 3.6 \times 10^{-11}$ M

$[Ag^+(aq)] = 6.0 \times 10^{-6}$ M

Answer: **6.0×10^{-6} M**

What is the concentration of chloride ions when silver chromate solid first starts to precipitate?

As $[Ag^+(aq)] = 6.0 \times 10^{-6}$ M when silver chromate starts to precipitate, the concentration of $Cl^-(aq)$ is given by:

$[Cl^-(aq)] = K_{sp}(AgCl) / [Ag^+(aq)] = (1.8 \times 10^{-10} / 6.0 \times 10^{-6})$ M $= 1.8 \times 10^{-9}$ M

$= 3.0 \times 10^{-5}$ M

Answer: **3.0×10^{-5} M**

ANSWER CONTINUES ON THE NEXT PAGE

What percentage of the chloride ion is precipitated before any silver chromate is precipitated?

When silver chromate first precipitates, $[Cl^-(aq)] = 3.0 \times 10^{-5}$ M. Initially, $[Cl^-(aq)] = 0.10$ M so the percentage that has precipitated as AgCl(s) at this point is:

$$\textbf{percentage precipitated} = \frac{(0.10 - 3.0 \times 10^{-5})}{0.10} \times 100\% = 99.97\%$$

Answer: **99.97%**