

Chemistry 192
Recitation Session Questions
March 5, 2018
Solutions

1. The solubility product of bismuth iodide (BiI_3) is 7.7×10^{-19} . Determine if a precipitate forms when 0.125 L of a solution that has $[\text{Bi}^{3+}] = 0.0035 \text{ M}$ is mixed with 0.259 L of a solution that has $[\text{I}^-] = 5.5 \times 10^{-6} \text{ M}$.

Answer

$$n_{\text{Bi}^{3+}} = (0.0035 \text{ mol L}^{-1})(0.125 \text{ L}) = 4.4 \times 10^{-4} \text{ mol}$$

$$[\text{Bi}^{3+}] = \frac{4.4 \times 10^{-4} \text{ mol}}{0.125 \text{ L} + 0.259 \text{ L}} = 1.1 \times 10^{-3} \text{ M}$$

$$n_{\text{I}^-} = (5.5 \times 10^{-6} \text{ mol L}^{-1})(0.259 \text{ L}) = 1.4 \times 10^{-6} \text{ mol}$$

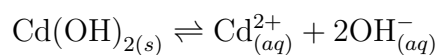
$$[\text{I}^-] = \frac{1.4 \times 10^{-6} \text{ mol}}{0.125 \text{ L} + 0.259 \text{ L}} = 3.6 \times 10^{-6} \text{ M}$$

$$Q = [\text{Bi}^{3+}][\text{I}^-]^3 = (1.1 \times 10^{-3})(3.6 \times 10^{-6})^3 = 5.1 \times 10^{-20} < K_{sp}$$

No precipitate forms.

2a. Cadmium hydroxide, $\text{Cd}(\text{OH})_2$ is slightly soluble in water with a solubility product constant of $K_{sp} = 2.5 \times 10^{-14}$. Calculate the solubility of cadmium hydroxide in water and the pH of a saturated cadmium hydroxide solution.

Answer:



	$[\text{Cd}^{2+}]$	$[\text{OH}^{-}]$
initial	0 M	0 M
change	s	$2s$
equilibrium	s	$2s$

$$s(2s)^2 = 4s^3 = 2.5 \times 10^{-14}$$

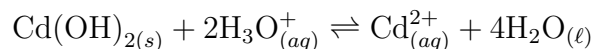
$$s = 1.8 \times 10^{-5} \text{ M} \quad [\text{OH}^{-}] = 2s = 3.6 \times 10^{-5}$$

$$\text{pOH} = -\log_{10}(3.6 \times 10^{-5}) = 4.43 \quad \text{pH} = 14.00 - \text{pOH} = 9.57$$

b. Calculate the solubility of cadmium hydroxide in a buffer whose pH is fixed at 6.00.

Answer:

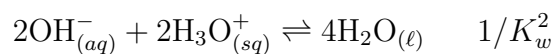
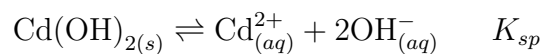
Method I:



Let K be the associated equilibrium constant so that

$$K = \frac{[\text{Cd}^{2+}]}{[\text{H}_3\text{O}^+]^2}$$

Now



add to give the first reaction. Then

$$K = \frac{K_{sp}}{K_w^2} = \frac{2.5 \times 10^{-14}}{(1.0 \times 10^{-14})^2} = 2.5 \times 10^{14}$$

$$\frac{[\text{Cd}^{2+}]}{(1.0 \times 10^{-6})^2} = 2.5 \times 10^{14}$$

$$[\text{Cd}^{2+}] = s = 2.5 \times 10^2 \text{ M}$$

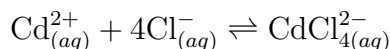
Method II:

$$[\text{Cd}^{2+}][\text{OH}^-]^2 = 2.5 \times 10^{-14}$$

$$[\text{Cd}^{2+}](1.0 \times 10^{-8})^2 = 2.5 \times 10^{-14}$$

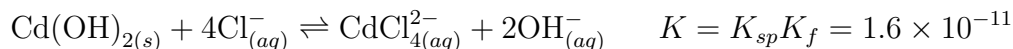
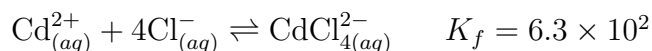
$$[\text{Cd}^{2+}] = s = 2.5 \times 10^2 \text{ M}$$

3. Cadmium hydroxide, $\text{Cd}(\text{OH})_2$ is slightly soluble in water with a solubility product constant of $K_{sp} = 2.5 \times 10^{-14}$. Cadmium ions form a coordination complex with chloride ions according to the reaction



with associated formation constant of $K_f = 6.3 \times 10^2$. Calculate the solubility of $\text{Cd}(\text{OH})_2$ in an aqueous 0.0100 M NaCl solution.

Answer:



$$K = \frac{[\text{CdCl}_4^{2-}][\text{OH}^-]^2}{[\text{Cl}^-]^4}$$

	$[\text{Cl}^-]$	$[\text{CdCl}_4^{2-}]$	$[\text{OH}^-]$
initial	0.0100 M	0 M	0 M
change	$-4s$	s	$2s$
equilibrium	$(0.0100 - 4s)$ M	s M	$2s$ M

$$K = 1.6 \times 10^{-11} = \frac{s(2s)^2}{(0.0100 - 4s)^4} \approx \frac{4s^3}{1.0 \times 10^{-6}}$$

$$s = 1.6 \times 10^{-6} \text{ M}$$