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A solution contains Mn^{2+}-ions 0.20 $\frac{\text{mol}}{\text{L}}$ and HCl 0.040 $\frac{\text{mol}}{\text{L}}$. The solution is saturated with H_2S: $[H_2S]$ = 0.10 $\frac{\text{mol}}{\text{L}}$. Will there be a precipitation of MnS?

$K_{sp_{\text{MnS}}} = 3.0 \times 10^{-14}$

Solution

A precipitation of MnS will be formed if $\left[\text{Mn}^{2+}\right] \times \left[\text{S}^{2-}\right] > K_{sp_{\text{MnS}}} \left(= 3.0 \times 10^{-14}\right)$.

The concentration of Mn^{2+} is known: 0.20 $\frac{\text{mol}}{\text{L}}$.

The concentration of S^{2-} is determined by the pH

$$\left[\text{S}^{2-}\right] = \frac{K_{a2_{\text{H}_2\text{S}}} \cdot \left[\text{HS}^-\right]}{\left[\text{H}^+\right]} = \frac{K_{a1_{\text{H}_2\text{S}}} \cdot K_{a2_{\text{H}_2\text{S}}} \cdot [\text{H}_2\text{S}]}{\left[\text{H}^+\right]^2}$$

and can be calculated:

$$\left[\text{S}^{2-}\right] = \frac{K_{a1_{\text{H}_2\text{S}}} \cdot K_{a2_{\text{H}_2\text{S}}} \cdot [\text{H}_2\text{S}]}{\left[\text{H}^+\right]^2} = \frac{\left(8.9 \times 10^{-8}\right) \times \left(1.0 \times 10^{-14}\right) \times 0.10}{(0.040)^2} = 5.6 \times 10^{-20}\ \frac{\text{mol}}{\text{L}}$$

Thus

$$\left[\text{Mn}^{2+}\right] \times \left[\text{S}^{2-}\right] = 0.20 \times 5.6 \times 10^{-20} = 1.1 \times 10^{-20} < K_{sp_{\text{MnS}}} \left(= 3.0 \times 10^{-14}\right)$$

So there will be no precipitation of MnS.