Marks 4

- The solubility product constant of $Fe(OH)_3$ is 1×10^{-39} M^4. What is the concentration of $Fe^{3+}(aq)$ in equilibrium with $Fe(OH)_3$ at pH 7.0?

As pH + pOH = 14.0 and pOH = $-\log_{10}([OH^-(aq)]$, $[OH^-(aq)] = 10^{-7.0}$.

The dissolution reaction and solubility product are:

$$Fe(OH)_3(s) \rightleftharpoons Fe^{3+}(aq) + 3OH^-(aq) \qquad K_{sp} = [Fe^{3+}(aq)][OH^-(aq)]^3$$

With $K_{sp} = 1 \times 10^{-39}$ and $[OH^-(aq)] = 10^{-7.0}$,

$$[Fe^{3+}(aq)] = \frac{K_{sp}}{[OH^-(aq)]^3} = \frac{(1 \times 10^{-39})}{(10^{-7.0})^3} = 1 \times 10^{-18} \text{ M}$$

ANSWER: **1×10^{-18} M**

To what value does the pH need to be increased to decrease the concentration of $Fe^{3+}(aq)$ to a single $Fe^{3+}(aq)$ ion per litre of solution?

A single $Fe^{3+}(aq)$ ion corresponds to:

$$\text{number of moles} = \frac{\text{number of ions}}{\text{Avogadro's number}} = \frac{1}{6.022 \times 10^{23}} = 1.66 \times 10^{-24} \text{ mol}$$

If this is in a litre of solution, $[Fe^{3+}(aq)] = 1.66 \times 10^{-24}$ M.

As $K_{sp} = [Fe^{3+}(aq)][OH^-(aq)]^3$,

$$[OH^-(aq)]^3 = \frac{K_{sp}}{[Fe^{3+}(aq)]} = \frac{(1 \times 10^{-39})}{(1.66 \times 10^{-24})} = 6 \times 10^{-16} \text{ M}^3$$

$$[OH^-(aq)] = 8 \times 10^{-6} \text{ M}$$

Thus, pOH = $-\log_{10}([OH^-(aq)]) = -\log_{10}(8 \times 10^{-6}) = 5$ and as pH = 14 – pOH,

pH = 14 – 5 = 9

ANSWER: **9**