Answer on Question #52868 – Chemistry – General chemistry

Question:

At STP, a galvanic cell was set up having the following half-reactions.
$Fe^{2+}(aq) + 2e^- \rightarrow Fe(s)$ -0.41
$Cu^{2+}(aq) + 2e^- \rightarrow Cu(s)$ 0.34

The copper half-cell contained 100.0 mL of 1.00 M $CuSO_4$, The lead half-cell contained 50.0 mL of 0.100 M $FeSO_4$, to which was added 50.0 mL of 0.300 M NaOH. The cell potential was measured to be 1.155 V. What is the concentration of Fe^{2+} in the iron half-cell?

Solution:

$$E = E^0 - \frac{RT}{nF} log \frac{c(Fe^{2+})}{c(Cu^{2+})}$$

$$E = E^0 - \frac{0.0592}{2} log \frac{c(Fe^{2+})}{c(Cu^{2+})}$$

$$E^0 = \varphi(Cu^{2+}/Cu) \ - \varphi(Fe^{2+}/Fe) \ = 0.34 + 0.41 = 0.75$$

$$1.115 = \ 0.75 - \frac{0.0592}{2} log \frac{c(Fe^{2+})}{c(Cu^{2+})}$$

$$log \frac{c(Fe^{2+})}{c(Cu^{2+})} = \ -2 \cdot (\frac{1.155 - 0.75}{0.0592})$$

$$\frac{c(Fe^{2+})}{c(Cu^{2+})} = 2 \cdot 10^{-14}$$

$$c(Fe^{2+}) = 2 \cdot 10^{-14} \, mol \, L^{-1}$$

Such a low concentration can be explained with the formation of insoluble iron (II) hydroxide with NaOH addition:

$$Fe^{2+} + \ 2OH^- = Fe(OH)_2 \downarrow, K_s = 1.4 \cdot 10^{-15}$$

Answer: $2 \cdot 10^{-14}$ mol L^{-1}