The following cell was constructed and produced a cell voltage of 0.588 V. Calculate the concentration of the NaI(aq).

$$\text{Pb}(s) \mid \text{PbI}_2(s) \mid \text{NaI}(aq) \parallel \text{NaCl}(aq)(0.100 \text{ M}) \mid \text{AgCl}(s) \mid \text{Ag}(s)$$

$$\text{PbI}_2(s) + 2e^- \leftrightarrow \text{Pb}(s) + 2\text{I}^- \quad E^0 = -0.366 \text{ V}$$

$$\text{AgCl}(s) + e^- \leftrightarrow \text{Ag}(s) + \text{Cl}^- \quad E^0 = 0.222 \text{ V}$$
The following cell was constructed and produced a cell voltage of 0.588 V. Calculate the concentration of the NaI(aq).

\[
\begin{align*}
\text{Pb(s)} & \mid \text{PbI}_2(s) \mid \text{NaI(aq)} \parallel \text{NaCl(aq)(0.100 M)} \mid \text{AgCl(s)} \mid \text{Ag(s)} \\
\text{PbI}_2(s) & + 2e^- \leftrightarrow \text{Pb(s)} + 2\text{I}^- \quad E^0 = -0.366 \text{ V} \\
\text{AgCl(s)} + e^- & \leftrightarrow \text{Ag(s)} + \text{Cl}^- \quad E^0 = 0.222 \text{ V}
\end{align*}
\]

\[
E = E_+ - E_- = 0.588 \text{ V}
\]

\[
E_+ = E^0_+ - 0.05916 \log [\text{Cl}^-] = 0.222 - 0.05916 \log(0.100) = 0.281 \text{ V}
\]

\[
E_- = E^0_- - 0.05916/2 \log [\text{I}^-]^2 = -0.366 - 0.05916/2 \log([\text{I}^-]^2)
\]

\[
0.588 = 0.281 - \{ -0.366 - 0.05916/2 \log([\text{I}^-]^2) \}
\]

\[
10^{2 \times (0.588 - 0.281 - 0.366) / 0.05916} = [\text{I}^-]^2 = 0.0100
\]

\[
[\text{I}^-] = 0.100 \text{ M}
\]

Or

\[
E = (E^0_+ - E^0_-) - 0.05916/2 \log [\text{I}^-]^2/[\text{Cl}^-]^2
\]

\[
0.588 = (0.222 - (-.366)) - 0.05916/2 \log [\text{I}^-]^2/[0.100]^2
\]

\[
0.000 = 0.05916/2 \log [\text{I}^-]^2/[0.100]^2
\]

Therefore, \([\text{I}^-] = [\text{Cl}^-] = 0.100 \text{ M}\)