• Calculate the standard electrochemical potential for the following reaction.

\[ 3\text{Zn(s)} + 2\text{Cr}^{3+}(aq) \rightarrow 3\text{Zn}^{2+}(aq) + 2\text{Cr(s)} \]

The half reactions and potentials are:

\[
\text{Cr}^{3+}(aq) + 3e^- \rightarrow \text{Cr(s)} \quad E^\circ = -0.74 \text{ V}
\]

\[
\text{Zn(s)} \rightarrow \text{Zn}^{2+}(aq) + 2e^- \quad E^\circ = +0.76 \text{ V (reversed for oxidation required)}
\]

Hence, \( E^\circ = ((-0.74) + (+0.76)) \text{ V} = +0.02 \text{ V} \)

Answer: +0.02 V

Use the Nernst equation to calculate the relative cation concentrations at 298 K for which the cell potential, \( E = 0 \).

The Nernst equation gives \( E_{\text{cell}} = E^\circ - \frac{RT}{nF} \log(Q) \). \( E_{\text{cell}} = 0 \) when:

\[
E^\circ = \frac{RT}{nF} \log(Q) = \frac{RT}{nF} \log(K_{eq})
\]

The ratio of cation concentrations is just \( Q = \frac{[\text{Zn}^{2+}(aq)]^3}{[\text{Cr}^{2+}(aq)]^2} \). The process involves 6e\(^-\) so \( n = 6 \) and \( Q \) can be obtained using the \( E^\circ = +0.02 \text{ V} \):

\[
Q = 10^{\frac{nFE^\circ}{RT}/2.303} = 10^{\left(\frac{6 \times 96485 \times +0.02}{2.303 \times 8.314 \times 298}\right)} = 100
\]

Answer: 100

• Fluorine and chlorine are both in Group 17. Briefly explain why HF exhibits hydrogen bonding but HCl does not.

Fluorine is more electronegative than chlorine so the H-F molecule is much more polar; the partial negative charge on F in HF is larger than that on Cl in HCl, as is the partial positive charge on H. This leads to a stronger H-bonding interaction.

In addition, the smaller size of F allows closer approach between HF molecules and stronger interactions.