Problem 11-09 Potential of redox electrodel

5.4 g of ferric chloride and 2 g of ferrous chloride were dissolved in 2 dm^3 of the distilled water. Thin platinum wire was then immersed into this solution. Assuming that all activity coefficients are equal to one calculate the reduction potential of this half-cell at the temperature of 25 °C. For the standard state of the electrolyte choose the state of infinite dilution, $c^{st} = 1$ mol dm^{-3}. Additional data:

$$M_{Fe} = 55.847 \text{ g mol}^{-1},\ M_{Cl} = 35.453 \text{ g mol}^{-1},\ E^{\ominus}(Fe^{3+}|Fe^{2+}) = 0.771 \text{ V}.$$

$$[\ E_{Fe^{3+}|Fe^{2+}} = 0.7391 \text{ V}\ ]$$

Solution:

Concentration of the electrolyte:

$V = 2$ dm^3

$m_{FeCl2} = 5.4$ g , $M_{FeCl2} = 55.847 + 2 \cdot 35.453 = 126.753$ g mol^{-1}

$$c_{FeCl2} = \frac{m_{FeCl_2}}{M_{FeCl_2} \cdot V} = \frac{5.4}{126.753 \cdot 2} = 2.13 \cdot 10^{-2} \text{ mol dm}^{-3}$$

$m_{FeCl3} = 2$ g , $M_{FeCl3} = 55.847 + 3 \cdot 35.453 = 162.206$ g mol^{-1}

$$c_{FeCl3} = \frac{m_{FeCl_3}}{M_{FeCl_3} \cdot V} = \frac{2}{162.206 \cdot 2} = 6.165 \cdot 10^{-3} \text{ mol dm}^{-3}$$

Elektrode reduction reaction:

$Fe^{3+} + e^- \rightarrow Fe^{2+}$ $\qquad E^{\ominus}(Fe^{3+}|Fe^{2+}) = 0.771$ V

$$E(Fe^{3+}|Fe^{2+}) = E^{\ominus}(Fe^{3+}|Fe^{2+}) - \frac{\boldsymbol{RT}}{\boldsymbol{F}} \cdot \ln \frac{a_{Fe^{2+}}}{a_{Fe^{3+}}}$$

$FeCl_2 = Fe^{2+} + 2\ Cl^-$	$FeCl_3 = Fe^{3+} + 3\ Cl^-$
$a_{Fe^{2+}} = \gamma_+ \cdot \frac{c_{Fe^{2+}}}{c^{st}} \approx c_{FeCl_2}$ $(c^{st} = 1 \text{ mol dm}^{-3})$	$a_{Fe^{3+}} = \gamma_+ \cdot \frac{c_{Fe^{3+}}}{c^{st}} \approx c_{FeCl_3}$ $(c^{st} = 1 \text{ mol dm}^{-3})$

$$E(Fe^{3+}|Fe^{2+}) = 0.771 - \frac{8.314 \cdot 298.15}{96485.3} \cdot \ln \frac{2.13 \cdot 10^{-2}}{6.165 \cdot 10^{-3}} = 0.771 - 0.03185$$

$E(Fe^{3+}|Fe^{2+}) = 0.7391$ V