(16.2) What fraction of neptunium is in the +4 state in a 0.1 M $FeSO_4$ solution of acidity 1 M H^+, assuming an initial Np(V) concentration of 9.4 mM ?

Use eqn. 9.4, $E=E^0-(\boldsymbol{R}T/n\boldsymbol{F})\ln(\text{red/ox})$, for both Np and Fe and put both E:s equal.

First some constants and given values:

$R := 8.31451\cdot joule\cdot mole^{-1}\cdot K^{-1}$ $\quad q_e := 1.6021773\cdot 10^{-19}\cdot coul$ $\quad N_A := 6.022137\cdot 10^{23}\cdot mole^{-1}$

$F := q_e\cdot N_A$ $\quad n := 1$ $\quad T := (25 + 273.15)\cdot K$

Eqn. 9.4 can be rewritten as: $E=E^0+(\boldsymbol{R}T/n\boldsymbol{F})\ln(\text{ox/red})$

$E_{0Np} := 739\cdot mV$ In 1 M $HClO_4$, from Handbook of Chem. and Phys., 62nd Ed.

$C_{Np} := 9.4\cdot 10^{-3}\cdot mole\cdot liter^{-1}$ $\quad E_{Np}(X_{Np}) := E_{0Np} + \frac{R\cdot T}{n\cdot F}\cdot ln(X_{Np})$ $\quad X_{Np}=(Np)_{ox}/(Np)_{red}$

$E_{0Fe} := 770\cdot mV$ In 1 M $HClO_4$, from Handbook of Chem. and Phys., 62nd Ed.

$C_{Fe} := 0.1\cdot mole\cdot liter^{-1}$ $\quad E_{Fe}(X_{Fe}) := E_{0Fe} + \frac{R\cdot T}{n\cdot F}\cdot ln(X_{Fe})$ $\quad X_{Fe}=(Fe)_{ox}/(Fe)_{red}$

Reduction reaction: $Fe^{2+} + NpO_2^+ + 4H^+ = Fe^{3+} + Np^{4+} + 2H_2O$

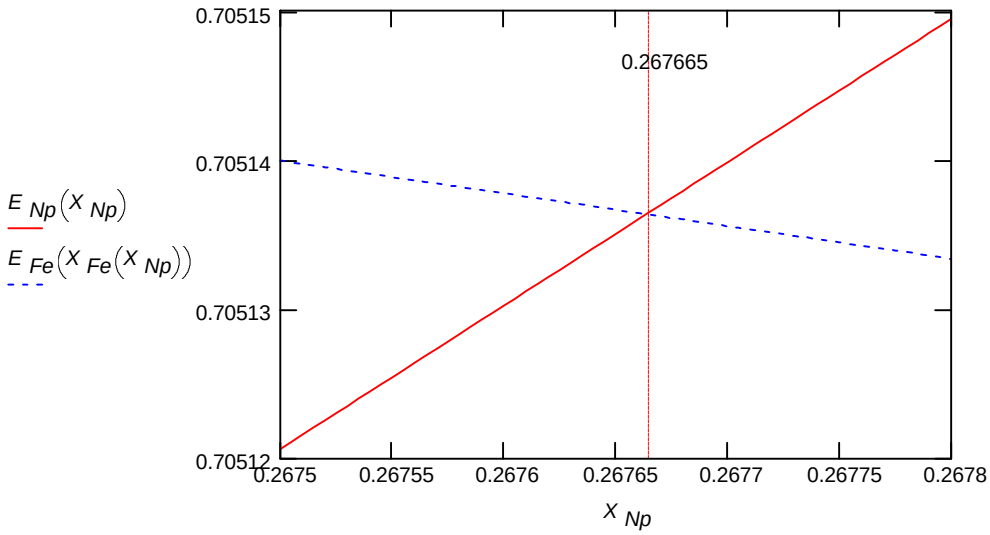
This gives the requirement that concentrations of Fe^{3+} and Np^{4+} should be equal.

$C_{Np4}(X_{Np}) := \frac{C_{Np}}{1 + X_{Np}}$

$C_{Fe3}(X_{Np}) := C_{Np4}(X_{Np})$ $\quad C_{Fe2}(X_{Np}) := C_{Fe} - C_{Fe3}(X_{Np})$

$X_{Fe}(X_{Np}) := \frac{C_{Fe3}(X_{Np})}{C_{Fe2}(X_{Np})}$

$X_{Np} := 0.2675, 0.267505 .. 0.2678$



$X_{Np} := 0.267665$

$\frac{1}{1 + 0.267665} = 78.885\cdot \%$ Answer: 78.9%