1. During turnover of a lake, reduced bottom water is mixed with oxidized surface water. Assume that bottom and surface waters with the following compositions mix in a 1:1 ratio.

   Bottom water: \( \text{TOT}[\text{Fe(II)}] = 1.5 \times 10^{-3}; \text{TOT}[\text{S(II)}] = 3 \times 10^{-4}; \text{SO}_4^{2-} = 1.0 \times 10^{-3} \)

   Surface water: \( \text{O}_2(aq) = 3 \times 10^{-4}; \text{SO}_4^{2-} = 1.3 \times 10^{-3}; \text{NO}_3^- = 1.2 \times 10^{-4} \)

(a) Prepare a log \( c - p_e \) diagram for the mixture for the range \(-20 < p_e < 20\), assuming that solution pH is 7.5 and the ionic strength is fixed at 0.005 \( M \). Assume that the elements listed above can exist in the following oxidation states:

   Fe: \(+II\) or \(+III\); S: \(-II\) or \(+VI\); N: \(-III\), 0, or \(+V\); and O: \(-II\) or 0

   You should use Visual Minteq to generate the data for the concentrations of Fe, S, and N species as a function of \( p_e \). However, the current Visual Minteq database does not include \( O_2(aq) \) as a species, nor does it contain information about any \( O(0)/O(-II) \) redox reaction, so you should develop the data for the \( O_2(aq) \) curve separately and add that information to the spreadsheet and graph manually. Consider Fe(II)-OH and Fe(III)-OH complexes, but ignore all other complexes that might form. Also ignore any possible precipitation reactions. Plot data only in the concentration range \(-2 > \log c > -14\). (Hint: If Visual Minteq returns an error message when you scan across the \( p_e \) range of interest, try running it twice – once from \( p_e 0 \) to \( p_e 20 \), and then from \( p_e 0 \) to \( p_e -20 \).)

(b) Write the \( \text{TOT}e \) equation for the mixed solution, and find the solution composition at equilibrium.