

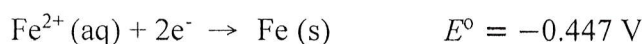
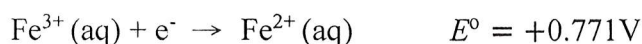


1. An ideal solution is made from 3 moles of benzene and 1 mole of toluene. Please calculate  $\Delta G_{\text{mixing}}$  and  $\Delta S_{\text{mixing}}$  at 298 K and 1 bar pressure. Is mixing a spontaneous process? (12%)

2. Please calculate **ionic strength** ( $I$ ) for (a) a 0.05 molar solution of NaCl and for (b) a  $\text{Na}_2\text{SO}_4$  solution of the same molality. You may use the equation shown below:

$$I = \frac{1}{2} \sum_i (m_i + Z_i^+{}^2 + m_i - Z_i^-{}^2) \quad Z_i: \text{charge number of an ion } i. \quad m_i: \text{molality of an ion. (12\%)}$$

3. Given the following reduction reactions and standard cell potential  $E^\circ$  values:



Calculate  $E^\circ$  for the half-cell reaction  $\text{Fe}^{3+}(\text{aq}) + 3\text{e}^- \rightarrow \text{Fe}(\text{s})$  (14%)

4. The decomposition of  $\text{N}_2\text{O}_5$  is an important process in tropospheric chemistry. The half-life for the first-order decomposition of this compound is  $2.05 \times 10^4$  s. How long will it take for a sample of  $\text{N}_2\text{O}_5$  to decay to 60% of its initial value? (12%)

5. When 1.5 moles of an ideal gas are heated at a constant pressure of 2.0 bar, the temperature increases from 300 K to 325 K. Given that the molar heat capacity at constant pressure is  $25.35 \text{ J mol}^{-1} \text{ K}^{-1}$ , calculate  $q$ ,  $\Delta H$  and  $\Delta U$ . (18%)

6. 4.5 moles of He gas expand isothermally at 308 K from  $48.0 \text{ cm}^3$  to  $547.5 \text{ cm}^3$ . Calculate  $\Delta G$  and  $\Delta A$  for the process. (20%)

7. The normal boiling point of isopropanol is 355.7 K, while the molar enthalpy of vaporization is  $44.0 \text{ kJ mol}^{-1}$ . Determine the vapor pressure at 298 K. (12%)