1. Calculate the standard potential, $U°$ from $\Delta G°$ for the following cells:

   - Chlor-alkali process to produce hydrogen and chlorine from a brine of NaCl (aqueous salt solution). Use the hydrogen reaction for an alkaline solution.

   $$\mathrm{Cl_2 + 2e^- \leftrightarrow 2Cl^-}$$

   $$\mathrm{H_2 + 2OH^- \leftrightarrow 2H_2O + 2e^-}$$

   - Acetic acid/oxygen fuel cell with acidic electrolyte, where the acetic acid reacts to form liquid water and carbon dioxide. The reaction at the negative electrode is:

   $$\mathrm{2H_2O + CH_3COOH \rightarrow 2CO_2 + 8H^+ + 8e^-}$$

2. Does the redox reaction as written below proceed spontaneously at 25 °C and standard conditions?

   $$\mathrm{2Ag^+ + H_2 \rightarrow 2Ag_{(s)} + 2H^+}$$

3. What is the standard half-cell potential for the oxidation of methane under acidic conditions? The reaction for methane is as follows:

   $$\mathrm{CH_{4(g)} + 2H_2O_{(\ell)} \rightarrow CO_2 + 8H^+ + 8e^-}$$

   Which element is oxidized and how does its oxidation state change?

4. Determine the equilibrium potential of the cell shown below:

   $$\mathrm{Pt_{(s)}\,|\,H_{2(g)}\,|\,HCl_{(aq)}\,||\,AgCl_{(s)}, Ag_{(s)}}$$

5. Consider the electrochemical reactions shown below. Mercury(I) chloride, also known as calomel, is a solid used in reference electrodes. The two reactions are:

   $$\mathrm{Zn \leftrightarrow Zn^{2+} + 2e^-}$$

   $$\mathrm{Hg_2Cl_2 + 2e^- \rightarrow 2Cl^- + 2Hg}$$

   (a) What is the overall chemical reaction?

   (b) Develop an expression for U, the equilibrium potential of the cell.

   (c) Write down an expression for the standard potential of the cell in terms of the standard Gibbs energies of formation.

   (d) Use standard half-cell potentials from the table to determine the standard Gibbs energy of formation for aqueous $ZnCl_2$. Why is this value different than the value for solid $ZnCl_2$?

Reference Text:

Electrochemical Engineering 1st Edition by Thomas F. Fuller (Author), John N. Harb (Author), John Wiley and Sons, 2018.