Electrochemistry problems (calculator required)

*Note: Some of these problems will require you to look up necessary information from your textbook. All the information you need **will** be there.*

1. Calculate ε° (at 25°C) for a galvanic cell based on the following half-reactions (in acidic solution):

   $MnO_4^-(aq) \longrightarrow Mn^{2+}(aq)$
   $I_2(aq) \longrightarrow IO_3^-(aq)$

   Calculate the voltage for a cell with a pH = 2.0, Mn^{2+} and IO_3^- are each 0.50 M, and I_2 and MnO_4^- are each 0.0010 M. Give the full cell notation for the reaction using the conditions given. **[ε° = 0.31 v, ε = 0.2166 v]**

2. Find the EMF of a cell in which a standard hydrogen electrode is coupled to an electrode with 0.1 M acetic acid and hydrogen gas at 1.0 bar pressure. *(Hint: acetic acid is a weak acid with a $K_a = 1.8 \times 10^{-5}$.)* **[ε = 0.1699 v]**

3. Find ε° and K (at 25°C) for the equilibrium

   $AgCl(s) \rightleftharpoons Ag^+(aq) + Cl^-(aq)$

   Will the EMF increase or decrease if the Ag^+ concentration is raised above 1 M? Explain your answer. **[ε° = -0.5777 v, K = 1.72×10^{-10}, decrease]**

4. A hydrogen/oxygen fuel cell has the net reaction

   $2H_2(g) + O_2(g) \rightleftharpoons 2H_2O(l)$

   and the cell is operated under acidic conditions. The cell is constructed with P_{H2} = 2.00 bar and P_{O2} = 0.20 bar and run at a temperature of 25°C. What voltage will be produced by the fuel cell? Is it possible to vary the pressure of hydrogen only (with the pressure of O_2 fixed at 0.20 bar) so that the battery produces 10.0 volts at 25°C? If so, what would the pressure of H_2 have to be to obtain this voltage? Do you think it would be possible to build such a battery? **[ε = 1.228 v, 7.37×10^{296} bar, NO]**

5. Using the following half-reactions (which occur in acidic solution):

$ClO_4^-(aq) \longrightarrow ClO_3^-(aq)$
$ClO_3^-(aq) \longrightarrow Cl^-(aq)$

Determine whether the chlorate (ClO_3^-) ion disproportionates spontaneously in acidic solution under standard conditions at 25°C. What are ε° and K for the disproportionation? **[ε° = 0.261 v, K = 2.96×10^{26}]**

6. Given the half-reactions

$MnO_4^-(aq) + 4H^+(aq) + 3e^- \rightleftharpoons MnO_2(s) + 2H_2O(l)$ ε° = 1.70 V
$MnO_2(s) + 4H^+(aq) + 2e^- \rightleftharpoons Mn^{+2}(aq) + 2H_2O(l)$ ε° = 1.23 V

Determine ε° for the half reaction

$MnO_4^-(aq) + 8H^+(aq) + 5e^- \rightleftharpoons Mn^{+2}(aq) + 4H_2O(l)$
[ε° = 1.512 v]

7. A concentration cell is set up as follows:

$Pt(s)|Fe^{+2}(aq, 0.200\ M), Fe^{+3}(aq, 0.00200\ M)||Fe^{+3}(aq, 0.15\ M), Fe^{+2}(aq, 0.004\ M)|Pt(s)$

0.500 litre beakers are used. A current of 2.0 A is drawn from the cell.

a) What voltage will be initially produced by the cell? **[0.2114 v]**
b) What voltage will the cell produce after ten minutes of operation? **[0.08583 v]**
c) How many minutes may the cell be run before it produces no voltage? **[33 min 52 sec]**

8. When the cell

$Pt(s)|F^-(aq, 1\ M)|F_2(g)||Cr^{+2}(aq, 1\ M)|Cr(s)$

is run, what will be produced at the anode and what at the cathode?
[O_2 at anode, H_2 at cathode]