Work Session 21a: Battery Design

Here are three pairs of half-cells, each shown in standard reduction form:
Standard reduction voltages are in the textbook. Write them after each half-cell.

1. $Zn^{2+}(aq) + 2\ e^- \rightarrow Zn(s)$ $\quad\quad$ $Sn^{4+}(aq) + 2\ e^- \rightarrow Sn^{2+}(aq)$

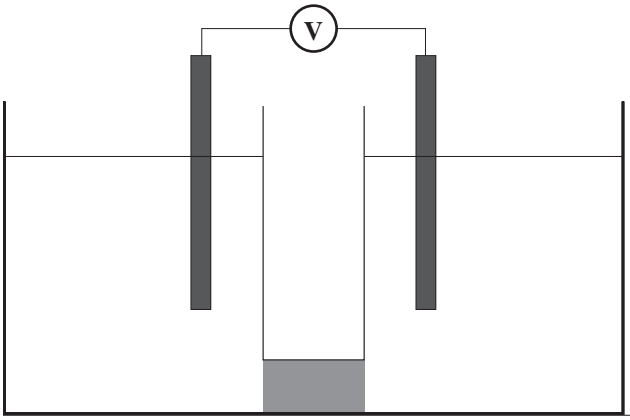
2. $Co^{3+}(aq) + 1\ e^- \rightarrow Co^{2+}(aq)$ $\quad\quad$ $Al^{3+}(aq) + 3\ e^- \rightarrow Al(s)$

3. $2\ H^+ + 2e^- \rightarrow H_2(g)$ $\quad\quad$ $Cu^{2+}(aq) + 2\ e^- \rightarrow Cu(s)$
   (show a tube bubbling H_2 gas onto a coiled Pt wire for this half-cell)

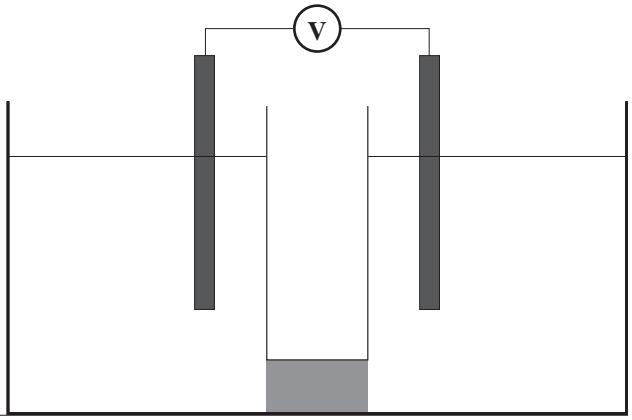
For each pair, reverse the appropriate half-cell, and indicate the following in the diagrams (show ion flow with species and arrows on each side of the porous plug at the bottom of the cell):

a) Voltage
b) anode and cathode
c) oxidation and reduction reactions
d) (+) and (-) electrodes
e) direction of electron flow
f) number of electrons in balanced equation
g) direction of ion flow (assume NO_3^- and K^+ ions as spectator ions if necessary)
h) content of each half-cell
i) substance used for electrode

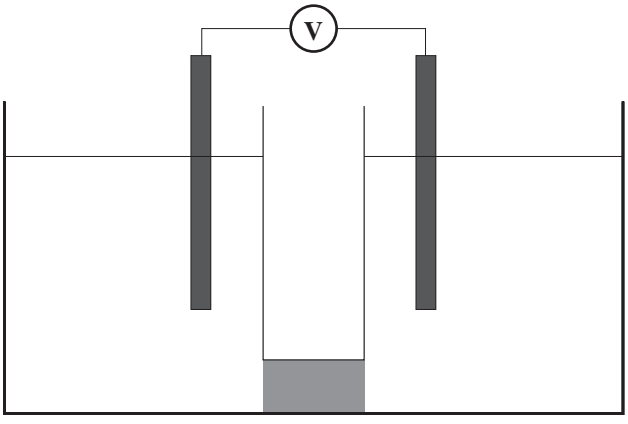
1.



2.



3.



Name_____ Grade_____ Date_____

The following two questions use the Nernst Equation:

4. For the electrolytic cell: $Sn(s) \mid Sn^{2+}(aq) \parallel Pb^{2+}(aq) \mid Pb(s)$

   a) What is E°?
   b) What is E when $[Sn^{2+}] = 0.01M$ and $[Pb^{2+}] = 1M$?
   c) What is E when the concentrations in b) are reversed?
   d) What is the ratio of $[Sn^{2+}]/[Pb^{2+}]$ which brings E = 0?

5. For the voltaic cell: $Ag(s) \mid Cl^{-}(aq) \mid AgCl(s) \parallel O_2(g) \mid H^{+}(aq), H_2O(l) \mid Pt$
   Find the half-cell reactions in the table and calculate the voltage. Balance the equation. Show the expression for Q for the reaction. Be careful with the exponents in Q, particularly for H^+. Remember that $pH = -\log[H^+]$.

   What is the E at pH = 0, 7, 14? Assume concentrations of 1M or pressures of 1 atm for everything except H^+.

6. Show the anode and cathode reactions and a simple diagram for the folllowing batteries: Dry cell, alkaline, silver button, lead-acid, nickel-metal hydride, and lithium-ion. Show a diagram and explain how a fuel cell works. Consult your textbook or Google for this question. Use another sheet if necessary.