AP Chemistry – Electrochemistry Problem Set

1) Calculate $E^\circ$, identify the cathode and anode, and give the overall balanced reaction. Assume that all concentrations are 1.0 M and that all partial pressures are 1.0 atm. Standard reduction potentials are found in the table. (Use the lowest possible coefficients. Include states-of-matter under SATP conditions in your answer.)

(a) $\text{Cr}^{3+}(aq) + \text{Cl}_2(g) \leftrightarrow \text{Cr}_2\text{O}_7^{2-}(aq) + \text{Cl}^-(aq)$

(b) $\text{Cu}^{2+}(aq) + \text{Mg}(s) \leftrightarrow \text{Mg}^{2+}(aq) + \text{Cu}(s)$

(c) $\text{IO}_3^-(aq) + \text{Fe}^{2+}(aq) \leftrightarrow \text{Fe}^{3+}(aq) + \text{I}_2(s)$

(d) $\text{Zn}(s) + \text{Ag}^+(aq) \leftrightarrow \text{Zn}^{2+}(aq) + \text{Ag}(s)$

2) Consider only the species below (at standard conditions) in answering the following questions. (Use data from Appendix E.)

$\text{Na}^+, \text{Cl}^-, \text{Ag}^+, \text{Ag}, \text{Zn}^{2+}, \text{Zn}, \text{Pb}$

(a) Which is the strongest oxidizing agent?
(b) Which is the strongest reducing agent?
(c) Which species can be oxidized by $\text{SO}_4^{2-}(aq)$ in acid? (Select all that apply.)
(d) Which species can be reduced by $\text{Al}(s)$? (Select all that apply.)

3) Use the table of standard reduction potentials to pick a reagent that is capable of each of the following oxidations (under standard conditions in acidic solution).

(a) oxidize $\text{Br}^-$ to $\text{Br}_2$ but not oxidize $\text{Cl}^-$ to $\text{Cl}_2$ (Select all that apply.)

(b) oxidize $\text{Mn}$ to $\text{Mn}^{2+}$ but not oxidize $\text{Ni}$ to $\text{Ni}^{2+}$

4) Under standard conditions, what reaction occurs, if any, when each of the following operations are performed? For the reactions that occur, write a balanced, net ionic equation and calculate $E^\circ$, $\Delta G^\circ$, and $K$ at 25°C. (If no reaction occurs, write NONE. Use the lowest possible coefficients. Include states-of-matter under SATP conditions in your answer.)

(a) Crystals of $\text{I}_2$ are added to a solution of $\text{NaCl}$
(b) $\text{Cl}_2$ gas is bubbled into a solution of $\text{NaI}$.
(c) A silver wire is placed in a solution of $\text{CuCl}_2$.
(d) An acidic solution of $\text{FeSO}_4$ is exposed to air.
5) Calculate $E^\circ$ for the following reaction using values of $\Delta G^\circ_f$ in Appendix C.

$$\text{CH}_3\text{OH}(l) + 3/2 \text{O}_2(g) \rightarrow \text{CO}_2(g) + 2 \text{H}_2\text{O}(l)$$

Will $E^\circ$ increase or decrease with an increase in temperature?

6) Calculate $K_{sp}$ for iron(II) sulfide given the following data.

$$\text{FeS}(s) + 2 e^- \rightarrow \text{Fe}(s) + \text{S}^{2-}(aq) \quad E^\circ = -1.01 \text{ V}$$

$$\text{Fe}^{2+}(aq) + 2 e^- \rightarrow \text{Fe}(s) \quad E^\circ = -0.44 \text{ V}$$

7) Consider the galvanic cell based on the following half-reactions.

$$\text{Au}^{3+} + 3 e^- \rightarrow \text{Au} \quad E^\circ = 1.50 \text{ V}$$

$$\text{Tl}^+ + e^- \rightarrow \text{Tl} \quad E^\circ = -0.34 \text{ V}$$

(a) Determine the overall cell reaction. (Use the lowest possible coefficient. Include states-of-matter under SATP conditions in your answer.)

(b) Calculate $\Delta G^\circ$ and $K$ for the cell reaction at 25°C.

(c) Calculate $E_{\text{cell}}$ at 25°C when $[\text{Au}^{3+}] = 3.7 \times 10^{-2} \text{ M}$ and $[\text{Tl}^+] = 5.0 \times 10^{-4} \text{ M}$.

8) Consider the cell described below.

$$\text{Al} | \text{Al}^{3+} (1.00 \text{ M}) \ || \text{Pb}^{2+} (1.00 \text{ M}) | \text{Pb}$$

Calculate the cell potential after the reaction has operated long enough for the $[\text{Al}^{3+}]$ to have changed by 0.40 mol/L. (Assume $T = 25^\circ\text{C}$.)

9) What mass of each of the following substances can be produced in 1.4 h with a current of 22 A?

(a) Co from aqueous Co$^{2+}$
(b) Hf from aqueous Hf$^{4+}$
(c) I$_2$ from aqueous KI
(d) Cr from molten CrO$_3$

10) It took 3.98 min with a current of 4.14 A to plate out all the silver from 0.403 L of a solution containing Ag$^+$. What was the original concentration of Ag$^+$ in the solution?

11) An unknown metal M is electrolyzed. It took 74.1 s for a current of 2.00 A to plate out 0.107 g of the metal from a solution containing M(NO$_3$)$_3$. Identify the metal.
12) What volume of F₂ gas, at 25°C and 1.00 atm, is produced when molten KF is electrolyzed by a current of 18.1 A for 1.93 hours? At which electrode does this reaction occur?

13) In the electrolysis of a sodium chloride solution, what volume of Cl₂(g) is produced in the same time it takes to produce 4.71 L of H₂(g), with both volumes measured at 0°C and 1.00 atm?