$\boxed{3CH_3OH + 4MnO_4^- \rightarrow 3HCOO^- + OH^- + 4MnO_2 + 4H_2O}$

AP Chemistry Review
Chapter ~~17~~ 18 – Electrochemistry

1. Use the half-reaction method to balance the following redox reactions:

   a) $Fe^{2+} + \overset{+6}{Cr_2O_7^{2-}} + H^+ \rightarrow Fe^{3+} + Cr^{3+} + H_2O$ (acidic solution)

Ox: $(Fe^{2+} \rightarrow Fe^{3+} + e^-) \times 6$

Red: $14H^+ + 6e^- + Cr_2O_7^{2-} \rightarrow 2Cr^{3+} + 7H_2O$

$\boxed{6Fe^{2+} + 14H^+ + Cr_2O_7^{2-} \rightarrow 6Fe^{3+} + 2Cr^{3+} + 7H_2O}$

   b) $\overset{-2}{CH_3OH} + \overset{+7}{MnO_4^-} \rightarrow \overset{+2}{HCOO^-} + \overset{+4}{MnO_2} + H_2O + OH^-$ (basic solution)

Ox: $(H_2O + CH_3OH \rightarrow HCOO^- + 4e^- + 5H^+) \times 3$

Red: $(4H^+ + 3e^- + MnO_4^- \rightarrow MnO_2 + 2H_2O) \times 4$

$\cancel{3H_2O} + 3CH_3OH + \cancel{16}\,1\,H^+ + 4MnO_4^- \rightarrow 3HCOO^- + \cancel{15H^+} + 4MnO_2 + \cancel{8}\,5\,H_2O$

$\boxed{3CH_3OH + \cancel{H^+} + 4MnO_4^- \rightarrow 3HCOO^- + 4MnO_2 + \cancel{5}\,4\,H_2O} + OH^-$

2. The following reaction takes place in a voltaic cell. Write equations for the half-reactions and the overall cell reaction. Write a cell diagram for the voltaic cell and calculate the value of E^o_{cell}.

$$Fe^{3+}(aq) + Sn^{2+}(aq) \rightarrow Fe^{2+}(aq) + Sn^{4+}(aq)$$

E^o_{red}

Ox $Sn^{2+} \rightarrow Sn^{4+} + 2e^-$ $-(0.154\ V)$

Red $2 \times (e^- + Fe^{3+} \rightarrow Fe^{2+})$ $+(0.771\ V)$

$Sn^{2+} + 2Fe^{3+} \rightarrow Sn^{4+} + 2Fe^{2+}$

$E^o_{cell} = -0.154 + (+0.771)$

$\boxed{Pt \mid Sn^{2+}(aq), Sn^{4+}(aq) \parallel Fe^{3+}(aq), Fe^{2+}(aq) \mid Pt}$

$\boxed{E^o_{cell} = 0.617\ V}$

3. Predict whether the following reaction will be spontaneous in the forward direction. Assume that all reactants and products are in their standard states.

$$2MnO_2(s) + 3ClO^-(aq) + 2OH^-(aq) \rightarrow 2MnO_4^-(aq) + 3Cl^-(aq) + H_2O(l)$$

E^o_{red}

Ox. anode $\overset{+4\ -2}{MnO_2} \rightarrow \overset{+7\ -2}{MnO_4^-}$ $-(+0.60V)$

Red: Cathode $\overset{+1\ -2}{ClO^-} \rightarrow \overset{-1}{Cl^-}$ $+0.890\ V$

$E^o_{cell} = 0.890 + (-0.60) = \boxed{+0.290V}$

Spontaneous

4. Describe the galvanic cell below, based on the half-reaction. (Assume that all concentrations are 1.0 M and that all partial pressures are 1.0 atm.)

$$MnO_4^- + 8H^+ + 5e^- \rightarrow Mn^{2+} + 4H_2O \qquad E^\circ = 1.51\ V$$

$$IO_4^- + 2H^+ + 2e^- \rightarrow IO_3^- + H_2O \qquad E^\circ = 1.60\ V$$

A. Identify the cathode and anode.
B. Give the overall balanced reaction.
C. Determine E° for the galvanic cells.

A. Cathode: IO_4^- half-rxn Anode: MnO_4^- half-rxn

B. $2Mn^{2+} + 3H_2O + 5IO_4^- \rightarrow 2MnO_4^- + 6H^+ + 5IO_3^-$

C. $E^\circ_{cell} = 1.60\ V - 1.51\ V = \boxed{0.09\ V}$

5. Determine the values of E°_{cell} and ΔG° for the following reaction:

$$\overset{0}{O_2}(g) + 4\overset{-1}{I^-}(aq) + 4\overset{+1}{H^+}(aq) \rightarrow 2\overset{+1\ -2}{H_2O}(l) + 2\overset{0}{I_2}(s)$$

$\Delta G^\circ = -nFE^\circ_{cell}$

$= -4(96{,}485\ \frac{C}{s})(0.694\ \frac{J}{C})$

$\Delta G^\circ = -267{,}842\ J$

$\boxed{\Delta G^\circ = -268\ kJ}$

E°_{red}

Ox: $I^- \rightarrow I_2$ $-(+0.535\ V)$

Red. $O_2 \rightarrow H_2O$ $+1.23$

$E^\circ_{cell} = 1.23 - 0.535\ V$

$\boxed{E^\circ_{cell} = 0.694\ V}$

6. What is the value of E_{cell} for the following reaction carried out in a voltaic cell? 25°C

$$Pb(s) + 2H^+(0.0025M) \rightarrow Pb^{2+}(0.85M) + H_2(g, 0.95atm)$$

$E_{cell} = E^\circ_{cell} - \frac{0.0591}{n} \log Q$

$E_{cell} = 0.13\ V - \frac{0.0591}{2} \log \frac{P_{H_2}[Pb^{2+}]}{[H^+]^2}$

$E_{cell} = 0.13 - \frac{0.0591}{2} \log\left[\frac{(0.95)(0.85)}{(0.0025)^2}\right] = \boxed{E_{cell} = -0.0263\ V}$

E°_{red}

Ox: $Pb \rightarrow Pb^{2+}$ $-(-.13)$

Red: $H^+ \rightarrow H_2$ 0

$E^\circ_{cell} = 0 + 0.13 = \boxed{0.13\ V}$

7. Electrolysis of a molten metal chloride (MCl_3) was done in a lab, using a current of 6.50 A for 23.28 minutes. At the end of the experiment, 1.41 g of the metal was deposited at the cathode. What is the metal?

$3e^- + M^{3+} \rightarrow M$

$6Cl^- \rightarrow 3Cl_2^0 + 6e^-$

$Ampere = \frac{C}{sec.}$

$\frac{23.28\ min}{} \cdot \frac{60\ sec.}{1\ min.} = 1397\ sec.$

$6.50 = \frac{C}{1397}$

$MM = \frac{g}{mol}$

$C = 9.1 \times 10^3\ C \cdot \frac{1\ mol\ e^-}{96{,}485\ C} \cdot \frac{1\ mol\ M}{3\ mol\ e^-} = 0.0314\ mol$

$MM = \frac{1.41\ g}{0.0314\ mol}$

$\boxed{MM = 44.9\ g/mol} \rightarrow$ Scandium