Key - ch 19 & 20 Review Problems

1. (A) spontaneous - salt particles ionize, spread thru the solution
   (B) spontaneous - dye particle spread thru solution
   (C) spontaneous - no outside intervention
   (D) nonspontaneous - needs outside intervention

2. $\Delta G = \Delta H - T\Delta S$

(A) $\Delta H = +25\ kJ$ $T\Delta S = (.0050\ kJ/K \cdot 300K) = +1.5\ kJ$ ΔG will be + nonspontaneous

(B) $\Delta H = +25\ kJ$ $T\Delta S = (.0100\ kJ/K \cdot 300K) = +3.0\ kJ$ ΔG will be + nonspontaneous

(C) $\Delta H = -10.\ kJ$ $T\Delta S = (.0050\ kJ/K \cdot 298K) = +1.49\ kJ$ ΔG will be - spontaneous

(D) $\Delta H = -10.\ kJ$ $T\Delta S = (-.0400\ kJ/K \cdot 200K) = -8\ kJ$ ΔG will be - spontaneous

3. (A) $CH_4(g) + 2O_2(g) \rightarrow CO_2(g) + 2H_2O(g)$

$\Delta H°rxn = [-393.5\ kJ/mol + (2 \cdot -241.82\ kJ/mol)] - [-74.8\ kJ/mol + (2 \cdot 0)]$
$= -882.14\ kJ/mol - -74.8\ kJ/mol = \boxed{-807.34\ kJ/mol}$

$\Delta S°rxn = [.2136\ kJ/mol\,K + (2 \cdot .18883\ kJ/mol\,K)] - [.1863\ kJ/mol\,K + (2 \cdot .2050\ kJ/mol\,K)]$
$= .59126\ kJ/mol\,K - .5963\ kJ/mol\,K = \boxed{-.00504\ kJ/mol\,K}$

$\Delta G°rxn = [-394.4\ kJ/mol + (2 \cdot -228.57\ kJ/mol)] - [-50.8\ kJ/mol + (2 \cdot 0)]$
$= -851.54\ kJ/mol - -50.8\ kJ/mol = \boxed{-800.74\ kJ/mol}$

(B) $P_4O_{10}(s) + 6H_2O(l) \rightarrow 4H_3PO_4(s)$ (use $H_3PO_4(aq)$)

$\Delta H°rxn = [4 \cdot -1288.3\ kJ/mol] - [-2940.1\ kJ/mol + (6 \cdot -285.83\ kJ/mol)]$
$\Delta H°rxn = -5153.2\ kJ/mol - -4655.08\ kJ/mol = \boxed{-498.12\ kJ/mol}$

$\Delta S°rxn = [4 \cdot .1582\ kJ/mol\,K] - [.228.9\ kJ/mol\,K + (6 \cdot .06991\ kJ/mol\,K)]$
$= .6328\ kJ/mol\,K - .64836\ kJ/mol\,K = \boxed{-.01556\ kJ/mol\,K}$

$\Delta G°rxn = [4 \cdot -1142.6\ kJ/mol] - [-2675.2\ kJ/mol + (6 \cdot -237.13\ kJ/mol)]$
$= -4570.4\ kJ/mol - -4097.98\ kJ/mol = \boxed{-472.42\ kJ/mol}$

oops

5. $H_2(g) + Cl_2(g) \rightleftharpoons 2HCl(g)$

$\Delta G° = [2 \cdot -95.27\ kJ/mol] - [0 + 0] = \boxed{-190.54\ kJ/mol}$

$K = e^{-\Delta G°/RT} = e^{-(-190.54)/(8.314 \cdot 298)} = \boxed{1.08}$

(4) $SF_4(g) + F_2(g) \rightarrow SF_6(g)$ $\quad \Delta G^\circ_{rxn} = -374\ kJ$

$\Delta G^\circ_{rxn} = [\Delta G^\circ_{SF_6}] - [\Delta G^\circ_{SF_4} + \Delta G^\circ_{F_2}]$

$-374\ kJ - [-1105\ kJ] - [\Delta G^\circ_{SF_4} + 0]$

$+731\ kJ = \Delta G^\circ_{SF_4}$

6. $2NO_2(g) \rightleftharpoons N_2O_4(g)$

$\Delta G^\circ = -RT \ln K$

$= -(8.314\ J/mol\,K)(298\ K) \ln\left[\frac{.50}{.21^2}\right] = -6015.91\ J/mol$

7. (A) $\overset{+6\ -2}{Cr_2O_7^{2-}} + \overset{1\ +1\ -2}{C_2H_4O} \rightarrow \overset{0\ +1\ -2}{C_2H_4O_2} + \overset{3+}{Cr}$

$3H_2O + 3C_2H_4O \rightarrow 3C_2H_4O_2 + 6H^+ + 6e^-$

$6e^- + 8H^+ + Cr_2O_7^{2-} \rightarrow 2Cr^{3+} + 4H_2O$

$3C_2H_4O + 8H^+ + Cr_2O_7^{2-} \rightarrow 3C_2H_4O_2 + 2Cr^{3+} + 4H_2O$

(B) $\overset{0}{Zn} + \overset{+5\ -2}{NO_3^-} \rightarrow Zn^{2+} + \overset{-3\ +1}{NH_4^+}$

$4Zn \rightarrow 4Zn^{2+} + 8e^-$

$8e^- + 10H^+ + NO_3^- \rightarrow NH_4^+ + 3H_2O$

$4Zn + 10H^+ + NO_3^- \rightarrow 4Zn^{2+} + NH_4^+ + 3H_2O$

8. (A) $\overset{+7\ -2}{MnO_4^-} + \overset{+3\ -2}{C_2O_4^{2-}} \rightarrow \overset{+4\ -2}{MnO_2} + \overset{+4\ -2}{CO_2}$

$3\,C_2O_4^{2-} \rightarrow 6\,CO_2 + 6e^-$

$6e^- + 8H^+ + 2\,MnO_4^- \rightarrow 2MnO_2 + 4H_2O + 8OH^-$

$+8OH^-$

$4\,8H_2O$

$3C_2O_4^{2-} + 4H_2O + 2MnO_4^- + 6CO_2 + 2MnO_2 + 8OH^-$

(B) $\overset{+1\ -2}{ClO^-} + \overset{+3\ -2\ +1}{Fe(OH)_3} \rightarrow \overset{-1}{Cl^-} + \overset{+6\ -2}{FeO_4^{2-}}$

$10\,OH^- + 2H_2O + 2Fe(OH)_3 \rightarrow 2\,FeO_4^{2-} + 10H_2O + 6e^-$

$+10\,OH^-$

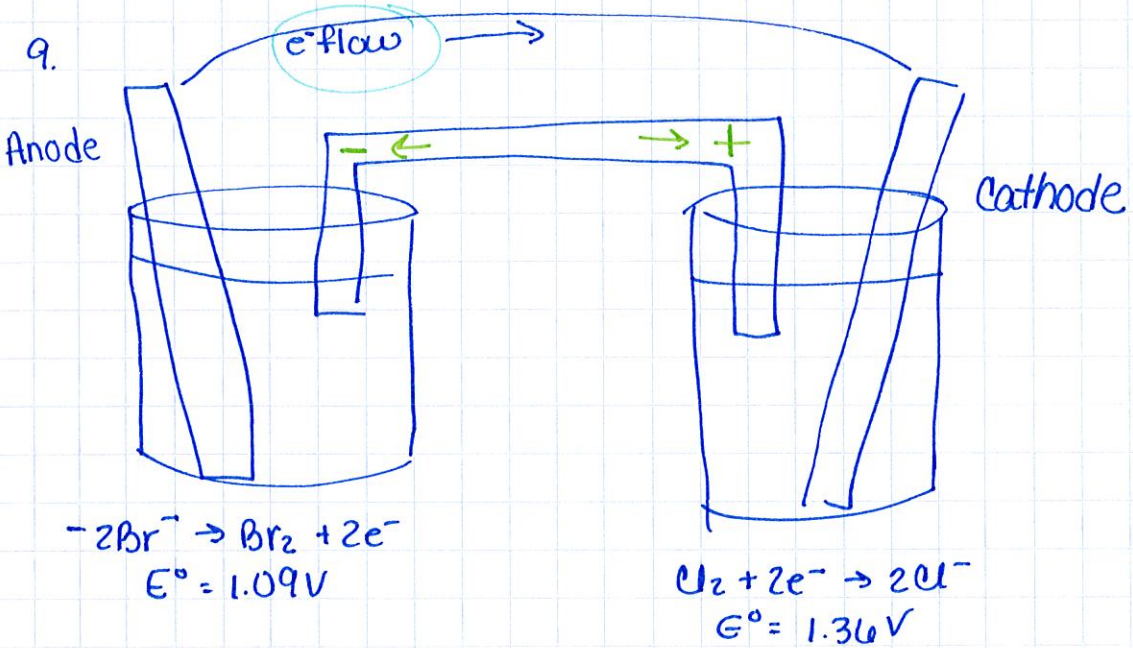
$6e^- + 8H^+ + 3ClO^- \rightarrow 3Cl^- + 3H_2O + 6OH^-$

$+6OH^-$

$6H_2O$

$2Fe(OH)_3 + 3ClO^- + 4OH^- \rightarrow 2FeO_4^{2-} + 5H_2O + 3Cl^-$

9.



$2Br^- \rightarrow Br_2 + 2e^-$

$E^\circ = 1.09V$

$Cl_2 + 2e^- \rightarrow 2Cl^-$

$E^\circ = 1.36V$

$E^\circ_{cell} = E^\circ_{red(cathode)} - E^\circ_{red(anode)}$

$E^\circ_{cell} = 1.36V - 1.09V = .27V$

$Zn + Fe^{2+} \rightarrow Zn^{2+} + Fe$ (Zn: ox; Fe^{2+}: red)

10.

(A) $E^\circ_{cell} = -.440V - -.763V = \boxed{+.323V}$

(B) $\Delta G^\circ = -nFE = -2(96485)(.323) = \boxed{74.91\ J/mol}$

(C) $\Delta G^\circ = -RT \ln K \quad K = e^{-\Delta G^\circ/RT}$

$K = e^{-74.91/(8.314 \cdot 298)} = \boxed{.970}$

11. $Fe + Ni^{2+} \rightarrow Fe^{2+} + Ni$ (Fe: ox; Ni^{2+}: red)

$E^\circ_{cell} = -.28V - -.440V = +.16V$

$\Delta G^\circ = -nFE = -2(96485)(.16) = -30.88\ J/mol$

$K = e^{-30.88/(8.314 \cdot 298)} = \boxed{.988}$

12. $Zn + Ni^{2+} \rightarrow Zn^{2+} + Ni$ (Zn: ox; Ni^{2+}: red)

(A) $E^\circ_{cell} = -.28V - -.763V = .483V$

(B) $E = E^\circ - \frac{.0592}{n} \log Q \qquad Q = \frac{[Zn^{2+}]}{[Ni^{+}]} = \frac{[.100]}{[3.00]} = \boxed{.0333}$

$E = .483V - \frac{.0592}{2} \log .0333$

$E = .483V - -.0437V = \boxed{.527V}$