Ch20 - 1-4, 13, 14, 15 + 17

1. a. electrons are the particle that is transferred in redox reactions

b. oxidizing agent (oxidants) are reduced so they gain e^-. = Strong Lewis Base

$HA + B: \longrightarrow HB + A^-$

base $\xrightarrow{+H^+}$ HB

$A + B \longrightarrow A^- + B^+$

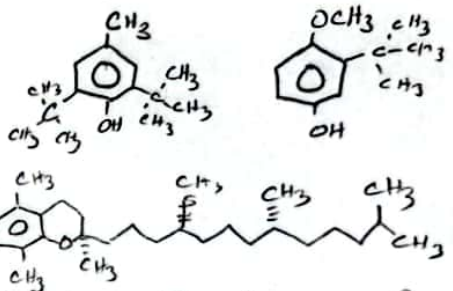
oxidant $A \xrightarrow{+e^-} A^-$

2. Antioxidant is a reducing agent. They have been oxidized but stop the propagation via resonant stabilization of the radical

Ex BHT - butylated hydroxy toluene

BHA - butylated hydroxy anisole

Vitamin E - tocopherol



3.a) Oxidation - the metal electrode would have M° atoms. The atoms in the electrode lose e^- to become cations

$M^0 \longrightarrow M^+ + e^-$

b) anode; anode undergoes oxidation, (-) source of electrons

c) when metals are ionized to form cations their radii decrease because Z_{eff}/pull increases

4. a) Additions - 1.0 M $AX_{2(aq)}$ and 1.0 M $BX_{2(aq)}$

- need a salt bridge (typically with NaCl)

b) Cathode = reduction = (+) $E'_{red}\ A^{2+} = -0.10\ V$ a stronger ox agent

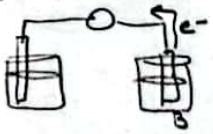
$E'_{red}\ B^{2+} = -1.10\ V$ - strong reducing agent

$B + A^{2+} \longrightarrow B^{2+} + A^-$

- reduction takes place @ A^{2+}

- More (+) E'_{red} = stronger reduction potential = better oxidizing agent

c.) $B_{(s)} \xrightarrow{e^-} A^{2+}$



d) $E^\circ_{cell} = E^\circ_{red} - E^\circ_{red(ox)} = -0.10 - (-1.10)\ V = 1.00\ V$

13. a) oxidation = lose of e^- ; means an increase in oxidation state

b) e^- appear on product side $Mg_{(s)} \rightarrow Mg^{2+} + 2e^-$

c) oxidant = oxidizing agent ; substance that has a high pull so removes e^- from another material ; is reduced

d) see (c)

14 a) reduction = gain of e^- ; means a decrease in oxidation state

b) e^- appear on the reactant side $F_2 + 2e^- \rightarrow 2F^-$

c) reductant = reducing agent ; substance that has a low pull on e^- so loses e^- to another material that has a higher pull ; is oxidized

d) see (c)

15. a) true - if viewing from ion formation ; if looking @ e^- density then it is sort of true. - oxyanions have central atoms that are oxidized by sharing more e^- or less e^-.

b.) false → $Fe^{3+} + 1e^- \rightarrow Fe^{2+}$; this is reduction so Fe^{3+} is an oxidizing agent

$Co^{2+} \rightarrow Co^{3+} + 1e^-$; this is oxidation so Co^{2+} is a reducing agent

c) true → redox reactions require a change in oxidation states

17. a) $\overset{+5\ -2}{I_2O_5(s)} + 5\overset{+2-2}{CO(g)} \rightarrow \overset{0}{I_2(s)} + 5\overset{+4-2}{CO_2}$

$10H^+ + I_2O_5 \rightarrow I_2 + 5H_2O + 10e^-$

$5(2e^- + H_2O + CO \rightarrow CO_2 + 2H^+)$

$= 10e^-$

b) $2\overset{2+}{Hg}_{(aq)} + \overset{-2\ +1}{N_2H_4(aq)} \rightarrow \overset{0}{2Hg_{(l)}} + \overset{0}{N_2(g)} + \overset{+1}{4H^+_{(aq)}}$

$4e^- + 2Hg^{2+} \rightarrow 2Hg$

$N_2H_4 \rightarrow N_2 + 4H^+ + 4e^-$

$= 4e^-$

c) $\overset{+1\ -2}{3H_2S_{(aq)}} + \overset{+1}{2H^+_{(aq)}} + \overset{+5\ -2}{2NO_3^-(aq)} \rightarrow \overset{0}{3S_{(s)}} + \overset{+2\ -2}{2NO_{(g)}} + \overset{+1\ -2}{4H_2O_{(l)}}$

$3H_2S \rightarrow 3S + 6H^+ + 6e^-$

$\times 3(2e^- + 4H^+ + 2NO_3^- \rightarrow 2NO + 2H_2O)$

$= 6e^-$

23. a) $Sn^{2+}_{(aq)} \rightarrow Sn^{4+}_{(aq)} + 2e^-$ oxidation

b) $2e^- + 4H^+ + TiO_{2(s)} \rightarrow Ti^{2+}_{(aq)} + 2H_2O$ reduction

c) $6e^- + 6H^+ + ClO_3^-{}_{(aq)} \rightarrow Cl^-_{(aq)} + 3H_2O$ reduction

d) $6e^- + 8H^+ + N_{2(g)} \rightarrow 2NH_4^+{}_{(aq)}$ reduction

e) $4OH^-_{(aq)} \rightarrow O_{2(g)} + 2H_2O_{(l)} + 4e^-$ oxidation

f) $2OH^- + H_2O + SO_3^{2-}{}_{(aq)} \rightarrow SO_4^{2-}{}_{(aq)} + \cancel{2H^+ + 2OH^-}^{H_2O} + 2e^-$ oxidation

g) $6e^- + \cancel{6H_2O}^{6OH^- - 6H^+} + N_{2(g)} \rightarrow 2NH_{3(g)} + 6OH^-$ reduction

29. $Ag_{(s)}/AgNO_{3(aq)} + Fe_{(s)}/FeCl_{3(aq)}$

$Fe_{(s)} + 2Ag^+ \rightarrow Fe^{2+} + 2Ag_{(s)}$

a) $Fe_{(s)}$ is oxidized + Ag^+ is reduced

b) $Fe_{(s)} \rightarrow Fe^{2+}_{(aq)} + 2e^-$ $Ag^+_{(aq)} + 1e^- \rightarrow Ag_{(s)}$

c) anode = oxidation = $Fe_{(s)}$ cathode = reduction = $Ag_{(s)}$

d) anode = (−) cathode = (+)

e) e^- travel from $Fe_{(s)}$ to Ag^+ through $Ag_{(s)}$ electrode

f) Cations move to Ag/Ag^+ half cell and anions move to $Fe_{(s)}/Fe^{2+}$ half cell

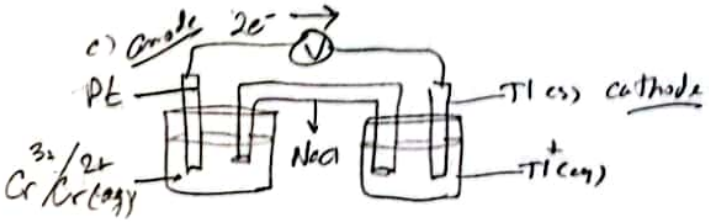
35 $Tl^{3+}_{(aq)} + 2Cr^{2+}_{(aq)} \rightarrow Tl^+_{(aq)} + 2Cr^{3+}_{(aq)}$ $E^\circ = 1.19\,V$

a) $Tl^{3+}_{(aq)} + 2e^- \rightarrow Tl^+_{(aq)}$ $Cr^{2+} \rightarrow Cr^{3+} + 1e^-$

b) $E^\circ_{cell} = E^\circ_{red}(Tl) - E^\circ_{red}(Cr^{2+}) \Rightarrow$ $1.19\,V = x - (-0.41\,V)$

$x = E^\circ_{red}(Tl) = 0.78\,V$

c)



39. $Ag^+ \Rightarrow 0.80V$
$Cu^{2+} \Rightarrow 0.34V$
$Ni^{2+} \Rightarrow -0.28V$
$Cr^{3+} \Rightarrow -0.74$

a) largest $Ag/Cr \Rightarrow E^\circ_{cell} = 0.80 - (-0.74) = 1.54V$

b) Smallest (+) Ni^{2+}/Cr^{3+} $E^\circ_{cell} = -0.28 - (-0.74) = 0.46V$
or Ag/Cu $E^\circ_{cell} = 0.80 - (0.34) = 0.46V$

53. $K_{eq} = 1.5 \times 10^{-4}$

$\Delta G = -RT \ln K_{eq}$

$E^\circ = \frac{RT}{nF} \ln K$

$\Delta G = -\left(8.31 \frac{J}{mol\,K}\right)(298\,K) \ln\left(1.5 \times 10^{-4}\right) = 21.8\ kJ$

$E^\circ = \frac{\left(8.31 \frac{J}{mol\,K}\right)(298\,K)}{2\,mol\ 96485 \frac{J}{V \cdot mol}} \cdot \ln\left(1.5 \times 10^{-4}\right) = -0.113\,V$

65. $Zn_{(s)} + Ni^{2+}_{(aq)} \rightarrow Zn^{2+}_{(aq)} + Ni_{(s)}$

$Ni^{2+} + 2e^- \rightarrow Ni$

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

a) $E^\circ_{cell} = E^\circ_{red}(Ni) - E^\circ_{red}(Zn) = -0.28 - (-0.76)$
$= 0.48\,V$

b) $E_{cell} = E^\circ_{cell} - \frac{RT}{nF} \ln Q$ $\quad Q = \frac{[Zn^{2+}]}{[Ni^{2+}]}$

$= 0.48V - \frac{\left(8.31 \frac{J}{mol\,K}\right)(298\,K)}{2\,mole^- \cdot 96485 \frac{J}{V \cdot mol}} \cdot \log\left(\frac{0.100}{3.00}\right)$

$= 0.52\,V$

c) $E^\circ_{cell} = 0.48V - \frac{0.0592}{2} \log\left(\frac{0.900}{0.200}\right)$

$= 0.46\,V$

76. $HgO_{(s)} + H_2O_{(l)} + 2e^- \rightarrow Hg_{(l)} + 2OH^-$
$Zn_{(s)} + 2OH^- \rightarrow ZnO_{(s)} + H_2O_{(l)} + 2e^-$

$E^\circ_{red}(HgO) = 0.098\,V$
$E^\circ_{cell} = +1.35\,V$

a) $HgO_{(s)} + Zn_{(s)} \rightarrow Hg_{(l)} + ZnO_{(s)}$

b) $E^\circ_{cell} = E^\circ_{red}(cat) - E^\circ_{red}(an)$
$1.35V = 0.098 - (x)$
$x = -1.25\,V$

c) $Zn^{2+} \rightarrow Zn_{(s)} + 2e^-$ $E^\circ_{red} = -0.76\,V$

This battery is happening in an alkaline environment which stabilizes Zn^{2+} as ZnO and not $Zn^{2+}_{(aq)}$
This stabilization decreases the driving force because ZnO is less apt to be reduced as compared to Zn^{2+}

9) $Cr^{3+} + 3e^- \rightarrow Cr_{(s)}$

$I = 7.60\ A$

$t = 2\ days$

a)

$$\frac{7.60\,C}{s} \left| \frac{2\,days}{1\,day} \right| \frac{24\,hrs}{1\,hr} \left| \frac{60\,min}{1\,min} \right| \frac{60\,s}{1\,min} \left| \frac{1\,mol\,e^-}{96485\,C} \right| \frac{1\,mol\,Cr}{3\,mol\,e^-} \left| \frac{51.9961\,g}{1\,mol\,Cr} \right.$$

$= 236\,g\,Cr$

b) $\frac{C}{s}$

$$0.250\,mol\,Cr \left| \frac{3\,mol\,e^-}{1\,mol\,Cr} \right| \frac{96485\,C}{1\,mol\,e^-} \left| \frac{}{8.00\,hr} \right| \frac{1\,hr}{60\,min} \left| \frac{1\,min}{60\,s} \right.$$

$= 2.51\ Amps$