Electrochemistry: Problem Set 10

Alphabetical Reduction Potential Table	
Half-reaction	E^o
$Ag^+ + 1\ e^- \rightarrow Ag\ (s)$	$E^o = +0.80$ V
$Al^{3+} + 3\ e^- \rightarrow Al\ (s)$	$E^o = -1.66$ V
$Au^{3+} + 3\ e^- \rightarrow Au\ (s)$	$E^o = +1.40$ V
$Cd^{2+} + 2\ e^- \rightarrow Cd\ (s)$	$E^o = -0.40$ V
$Cr^{3+} + 3e^- \rightarrow Cr(s)$	Eo = -0.74 V
$Cu^{2+} + 2\ e^- \rightarrow Cu\ (s)$	$E^o = +0.34$ V
$Cu^+ + 1\ e^- \rightarrow Cu\ (s)$	$E^o = +0.52$ V
$Fe^{3+} + 1e^- \rightarrow Fe^{2+}$	$E^o = +0.77$ V
$Hg^{2+} + 2\ e^- \rightarrow Hg(l)$	$E^o = +1.62$ V
$Li^+ + 1\ e^- \rightarrow Li\ (s)$	$E^o = -3.05$ V
$Ni^{2+} + 2\ e^- \rightarrow Ni\ (s)$	$E^o = -0.23$ V
$Pb^{4+} + 2\ e^- \rightarrow Pb^{2+}$	$E^o = +1.67$ V
$Pb^{2+} + 2\ e^- \rightarrow Pb$	$E^o = -0.13$ V
$Sn^{4+} + 4\ e^- \rightarrow Sn\ (s)$	$E^o = +0.0136$ V
$Sn^{4+} + 2\ e^- \rightarrow Sn^{2+}$	$E^o = +0.15$ V
$Sn^{2+} + 2\ e^- \rightarrow Sn\ (s)$	$E^o = -0.14$ V
$Zn^{2+} + 2e^- \rightarrow Zn\ (s)$	$E^o = -0.76$ V

A. For the following batteries (using the above table), determine the following:

a) the half reactions for the anode and cathode
b) the balanced reaction for the battery
c) the standard potential for the cell
d) the free energy change for the cell
e) the K_{eq} for the cell
f) if the battery works as set up

1. $Pt(s)\,|\,Fe^{2+}(aq), Fe^{3+}(aq)\,||\,Ag^+(aq)\,|\,Ag(s)$
2. $Pt(s)\,|\,Pb^{2+}(aq), Pb^{4+}(aq)\,||\,Al^{3+}(aq)\,|\,Al(s)$
3. $Cu(s)\,|\,Cu^{2+}(aq)\,||\,Cu^+(aq)\,|\,Cu(s)$
4. $Au(s)\,|\,Au^{3+}(aq)\,||\,Ag^+(aq)\,|\,Ag(s)$
5. $Li(s)\,|\,Li^+(aq)\,||\,Hg^{2+}(aq)\,|\,Hg(l)$
6. $Cd\,|\,Cd^{2+}\,||\,Hg^{2+}\,|\,Hg(l)$
7. $Ni\,|\,Ni^{2+}\,||\,Cd^{2+}\,|\,Cd$
8. $Sn\,|\,Sn^{4+}(aq)\,||\,Sn^{2+}(aq)\,|\,Sn$

B. For the above batteries, write the nomenclature that would make those batteries that do not work, work.

C. For the following batteries, determine the E_{cell} (using the above table):

9. $Cr(s)\,|\,Cr^{3+}$ (0.10 M) $\|\,Pb^{2+}$ (0.00001 M) $|\,Pb(s)$
10. $Zn(s)\,|\,Zn^{2+}$ (0.10 M) $\|\,Ni^{2+}$ (0.001M) $|\,Ni(s)$
11. $Sn(s)\,|\,Sn^{2+}$ (0.02 M) $\|\,Sn^{4+}$ (0.06 M), Sn^{2+} (1.0 M) $|\,Pt(s)$
12. $Pb(s)\,|\,Pb^{2+}$ (0.05M) $\|\,Ni^{2+}$ (0.10 M) $|\,Ni(s)$
13. $Pt(s)\,|\,Hg^{2+}$ (0.05M) $\|\,Li^{+}$ (0.0005M) $|\,Li(s)$

14. Identify which of the following reactions are reduction or oxidation reactions:

A) $Cu^{2+} + 1e^- \rightarrow Cu^+$

B) $Fe \rightarrow Fe^{2+} + 2e^-$

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

D) $Mg^{2+} + 2e^- \rightarrow Mg$

E) $Fe \rightarrow Fe^{3+} + 3e^-$

F) $Hg_2^{2+} + 2e^- \rightarrow 2Hg$

G) $Li \rightarrow Li^+ + 1e^-$

H) $Be^{2+} + 2e^- \rightarrow Be$

I) $F_2 + 2e^- \rightarrow 2F^-$

J) $Al \rightarrow Al^{3+} + 3e^-$

15. Given the following reactions, determine which reactant is oxidized and which reactant is reduced:

A) $Mn + Zn^{2+} \rightarrow Mn^{2+} + Zn$

B) $2Al^{3+} + 3Pb \rightarrow 2Al + 3Pb^{2+}$

C) $Na + Cl \rightarrow Na^+ + Cl^-$

D) $2Li + O \rightarrow 2Li^+ + O^{2-}$

E) $2Na + S \rightarrow 2Na^+ + S^{2-}$

16. Based on your responses to #15, above, which reactant is the oxidizing agent and which reactant is the reducing agent?

17. Based upon your new understanding of "simple" redox reactions, balance the following reactions:

A) $Cu^{2+} + Zn \rightarrow Cu + Zn^{2+}$

B) $Fe + Fe \rightarrow Fe^{2+} + Fe^{3+}$

C) $Be^{2+} + Al \rightarrow Be + Al^{3+}$

D) $Zn + Mg^{2+} \rightarrow Zn^{2+} + Mg$

E) $Fe + Al \rightarrow Al^{3+} + Fe^{3+}$

F) $Fe + Be^{2+} \rightarrow Fe^{2+} + Be$

Table of Half Reactions

IMPORTANT: When necessary, turn the reactions around to fit your needs – do NOT, however, change the contents of the half-reactions

$$MnO_4^- + 8H^+ + 5e^- \rightarrow Mn^{2+} + 4H_2O$$
$$O_2 + 2H_2O + 2e^- \rightarrow H_2O_2 + 2OH^-$$
$$Zn^{2+} + 2e^- \rightarrow Zn$$
$$Cu^{2+} + 2e^- \rightarrow Cu$$
$$2IO_3^- + 12H^+ + 10\ e^- \rightarrow I_2 + 6H_2O$$
$$NO_3^- + 4H^+ + 3\ e^- \rightarrow NO + 2H_2O$$
$$ClO_3^- + 6H^+ + 6\ e^- \rightarrow Cl^- + 3H_2O$$
$$Cr_2O_7^{2-} + 14H^+ + 6\ e^- \rightarrow 2Cr^{3+} + 7H_2O$$
$$NO_3^- + 3H^+ + 2\ e^- \rightarrow HNO_2 + H_2O$$
$$PbO + H_2O + 2\ e^- \rightarrow Pb + 2OH^-$$

18. Balance the following reactions by each of the first two methods of balancing redox reactions:

A) $Zn + NO_3^- \rightarrow Zn^{2+} + N_2\uparrow$

B) $NO_3^- + I_2 \rightarrow IO_3^- + NO_2\uparrow$

C) $Cu + NO_3^- \rightarrow Cu^{2+} + NO_2\uparrow$

D) $H_2O_2 + MnO_4^- \rightarrow Mn^{2+} + O_2\uparrow$

E) $CuS + NO_3^- \rightarrow Cu^{2+} + S + NO\uparrow$

F) $NO_3^- + Zn \rightarrow NH_3\uparrow + Zn(OH)_4^{2-}$

G) $ClO_3^- + I_2 \rightarrow IO_3^- + Cl^-$

H) $Cr_2O_7^{2-} + HNO_2 \rightarrow Cr^{3+} + NO_3^-$

I) $H_2SO_4 + HBr \rightarrow SO_2\uparrow + Br_2\uparrow$

J) $C + HNO_3 \rightarrow NO_2\uparrow + CO_2\uparrow$

19. Balance the following reactions from #1, above, by the third method: D, G and H.

20. Balance the following reactions by whichever methods you so desire:

A) $NO_3^- + Pb \rightarrow NO + PbO$

B) $Cl^- + Zn^{2+} \rightarrow ClO_3^- + Zn$

21. Draw a simple battery and label its parts.

22. Oxidation in a battery occurs at which electrode?

23. Reduction in a battery occurs at which electrode?

24. Draw and label an electrolytic cell.

25. Explain how corrosion on a piece of metal works as a battery.