Electrochemistry

1. For each of the following reactions: identify the oxidizing agent, balance the reaction using the half-reaction approach, calculate E°, state whether the reaction is spontaneous or not, and determine $\Delta G°$.
    a. $Fe^{2+} + Pb^{2+} \rightarrow Fe^{3+} + Pb(s)$

    b. $Ni^{2+} + Mg(s) \rightarrow Mg^{2+} + Ni(s)$

    c. $Fe^{2+} + O_2 \rightarrow Fe^{3+} + H_2O$

2. Calculate the equilibrium constant for reaction 1c.

3. Determine ΔG at 25°C for reaction 1a if $[Fe^{2+}]$ = 1.2 M, $[Fe^{3+}]$ = 26.5 nM, and $[Pb^{2+}]$ = 820 mM.

4. Sketch an electrochemical call (battery diagram) for reaction 1b. Show this as a complete sketch and as well as the shorthand method.

5. Consider each pair: determine with is the stronger oxidizing agent. For the first two, you can use the table at the end of the activity. In the last example, you will need to think about which molecule is more likely to get reduced.

Cl_2 vs. F_2 Ni^{2+} vs. Co^{2+} NO_3^- vs. $I_2(s)$ Na^+ vs. K^+

6. How many electrons are required to oxidize PH_3 to PO_4^{3-}?
    a. Use oxidation states to determine this (note that P is more electronegative than H).
    b. Confirm your answer using the half-reaction approach.

Standard Reduction Potentials at 298K, 1M, 1atm

HALF-REACTION	***E*° (V)**
$F_{2(g)} + 2\ e^- \rightarrow 2\ F^-_{(aq)}$	+2.87
$O_{3(g)} + 2\ H^+_{(aq)} + 2\ e^- \rightarrow O_{2(g)} + H_2O_{(l)}$	+2.07
$Co^{3+}_{(aq)} + e^- \rightarrow Co^{2+}_{(aq)}$	+1.82
$H_2O_{2(aq)} + 2\ H^+_{(aq)} + 2\ e^- \rightarrow 2\ H_2O_{(l)}$	+1.77
$PbO_{2(s)} + 4\ H^+_{(aq)} + SO_4^{2-}{}_{(aq)} + 2\ e^- \rightarrow PbSO_{4(s)} + 2\ H_2O_{(l)}$	+1.70
$Ce^{4+}_{(aq)} + e^- \rightarrow Ce^{3+}_{(aq)}$	+1.61
$MnO_4^-{}_{(aq)} + 8\ H^+_{(aq)} + 5\ e^- \rightarrow Mn^{2+}_{(aq)} + 4\ H_2O_{(l)}$	+1.51
$Au^{3+}_{(aq)} + 3\ e^- \rightarrow Au_{(s)}$	+1.50
$Cl_{2(g)} + 2\ e^- \rightarrow 2\ Cl^-_{(aq)}$	+1.36
$Cr_2O_7^{2-}{}_{(aq)} + 14\ H^+_{(aq)} + 6\ e^- \rightarrow 2\ Cr^{3+}_{(aq)} + 7\ H_2O_{(l)}$	+1.33
$MnO_{2(s)} + 4\ H^+_{(aq)} + 2\ e^- \rightarrow Mn^{2+}_{(aq)} + 2\ H_2O_{(l)}$	+1.23
$O_{2(g)} + 4\ H^+_{(aq)} + 4\ e^- \rightarrow 2\ H_2O_{(l)}$	+1.23
$Br_{2(l)} + 2\ e^- \rightarrow 2\ Br^-_{(aq)}$	+1.07
$NO_3^-{}_{(aq)} + 4\ H+_{(aq)} + 3\ e^- \rightarrow NO_{(g)} + 2\ H_2O_{(l)}$	+0.96
$2\ Hg^{2+}_{(aq)} + 2\ e^- \rightarrow Hg_2^{2+}{}_{(aq)}$	+0.92
$Hg_2^{2+} + 2\ e^- \rightarrow 2\ Hg_{(l)}$	+0.85
$Ag^+_{(aq)} + e^- \rightarrow Ag_{(s)}$	+0.80
$Fe^{3+}_{(aq)} + e^- \rightarrow Fe^{2+}_{(aq)}$	+0.77
$O_{2(g)} + 2\ H^+_{(aq)}\ 2\ e^- \rightarrow H_2O_{2(aq)}$	+0.68
$MnO_4^-{}_{(aq)} + 2\ H_2O_{(l)} + 3\ e^- \rightarrow MnO_{2(s)} + 4\ OH^-_{(aq)}$	+0.59
$I_{2(s)} + 2\ e^- \rightarrow 2\ I^-_{(aq)}$	+0.53
$O_{2(g)} + 2\ H_2O + 4\ e^- \rightarrow 4\ OH^-_{(aq)}$	+0.40
$Cu^{2+}_{(aq)} + 2\ e^- \rightarrow Cu_{(s)}$	+0.34
$AgCl_{(s)} + e^- \rightarrow Ag_{(s)} + Cl^-_{(aq)}$	+0.22
$SO_4^{2-}{}_{(aq)} + 4\ H^+_{(aq)} + 2\ e^- \rightarrow SO_{2(g)} + 2\ H_2O_{(l)}$	+0.20
$Cu^{2+}_{(aq)} + e^- \rightarrow Cu^+_{(aq)}$	+0.15
$Sn^{4+}_{(aq)} + 2\ e^- \rightarrow Sn^{2+}_{(aq)}$	+0.13
$2\ H^+_{(aq)} + 2\ e^- \rightarrow H_{2(g)}$	0.00
$Pb^{2+}_{(aq)} + 2\ e^- \rightarrow Pb_{(s)}$	-0.13
$Sn^{2+}_{(aq)} + 2\ e^- \rightarrow Sn_{(s)}$	-0.14
$Ni^{2+}_{(aq)} + 2\ e^- \rightarrow Ni_{(s)}$	-0.25
$Co^{2+}_{(aq)} + 2\ e^- \rightarrow Co_{(s)}$	-0.28
$PbSO_{4(s)} + 2\ e^- \rightarrow Pb_{(s)} + SO_4^{2-}{}_{(aq)}$	-0.31
$Cd^{2+}_{(aq)} + 2\ e^- \rightarrow Cd_{(s)}$	-0.40
$Fe^{2+}_{(aq)} + 2\ e^- \rightarrow Fe_{(s)}$	-0.44
$Cr^{3+}_{(aq)} + 3\ e^- \rightarrow Cr_{(s)}$	-0.74
$Zn^{2+}_{(aq)} + 2\ e^- \rightarrow Zn_{(s)}$	-0.76
$2\ H_2O_{(l)} + 2\ e^- \rightarrow H_{2(g)} + 2\ OH^-_{(aq)}$	-0.83
$Mn^{2+}_{(aq)} + 2\ e^- \rightarrow Mn_{(s)}$	-1.18
$Al^{3+}_{(aq)} + 3\ e^- \rightarrow Al_{(s)}$	-1.66
$Be^{2+}_{(aq)} + 2\ e^- \rightarrow Be_{(s)}$	-1.85
$Mg^{2+}_{(aq)} + 2\ e^- \rightarrow Mg_{(s)}$	-2.37
$Na^+_{(aq)} + e^- \rightarrow Na_{(s)}$	-2.71
$Ca^{2+}_{(aq)} + 2\ e^- \rightarrow Ca_{(s)}$	-2.87
$Sr^{2+}_{(aq)} + 2\ e^- \rightarrow Sr_{(s)}$	-2.89
$Ba^{2+}_{(aq)} + 2\ e^- \rightarrow Ba_{(s)}$	-2.90
$K^+_{(aq)} + e^- \rightarrow K_{(s)}$	-2.93
$Li^+_{(aq)} + e^- \rightarrow Li_{(s)}$	-3.05