Chapter 19 Electrochemistry Math Summary

Relating Standard Cell Potential to Standard Half Cell Potentials

$E^\circ_{cell} = E^\circ_{oxidation} + E^\circ_{reduction}$ (standard conditions assume 1.0 M concentrations)

Relating Half Cell Potentials when Written in Opposite Directions

$E^\circ_{ox} = -E^\circ_{red}$ for half reactions written in opposite directions

Relating Standard Cell Potentials to ΔG

$\Delta G^\circ = -nFE^\circ_{cell}$ (to give answer in kJ, use F = 96.485)

F = 96,500 C/mol

n=number of electrons transferred

Relating Actual Cell Potential to Standard Cell Potential when Concentrations aren't 1.0-M

$E_{cell} = E^\circ_{cell} - [0.0592/n] \log Q$ (Q = ratio of actual concentrations)

Relating Standard Cell Potential to Equilibrium Constant

$\log K = nE^\circ/0.0592$

Relating Actual Cell Potential to Actual Concentrations in Concentration Cells

$E_{cell} = -[0.0592/n] \log Q$ for concentration cells, where anode and cathode differ only in concentration, but otherwise have same ions

Relating # of Moles of Electrons Transferred as a Function of Time and Current in Electrolysis

1 mol e^- = 96,500 C

moles of electrons = [current (A)•time (sec)]/96,500 for electrolysis, moles, current, and time are related.

rearranged: time (sec)=(moles of electrons)(96500)/current (in A)

Note: 3600 sec/hour

so time (hours)=(moles of electrons)(26.8)/current (in A)

Assigning Oxidation Numbers

This is a more complete set of rules than your text book. It always works.

Use these rules in order.
The sum of all oxidation numbers of all elements = charge on substance

		Oxidation Number:	Examples:
1.	**Atoms in their elemental state**	=0	Fe, H_2, O_2
2.	**Monatomic ions**	=charge	F^{1-}, Na^{1+}, Fe^{3+}

IN COMPOUNDS

3.	**Group 1A**	=+1	NaCl, KNO_3
4.	**Group 2A**	=+2	MgO
5.	**Fluorine**	=-1	HF, ClF
6.	**Hydrogen**	=+1	H_2O
7.	**Oxygen**	=-2	SO_2, $HClO_4$
8.	**Group 7A**	=-1	HCl
9.	**Group 6A**	=-2	PbS_2

Try these:

SO_2, $HClO_4$, SO_3, PCl_5, NO_2, SO_4^{2-}, NO_3^{1-}, NO_2^{1-}, ClF_3, F_2

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Balancing Oxidation-Reduction Reactions

1. Assign oxidation numbers.

2. Separate into oxidation and reduction half reactions.

3. Balance each half reaction using the following steps:
   a. Balance all elements except oxygen or hydrogen.
   b. Balance oxygen by adding H_2O.
   c. Balance hydrogen by adding H^+.
   d. Balance charge by adding electrons:
      Electrons go on the RIGHT (product side) for OXIDATION reactions.
      Electrons go on the LEFT (reactant side) for REDUCTION reactions.
   e. In BASIC solution, do this additional step:
      For every H^+, add OH^- to BOTH sides of the reaction.
      Combine $H^+ + OH^-$ into H_2O.
      Cancel out any waters that appear on both sides.

   You should now have a balanced half reaction.

4. Multiply balanced half reactions so an equal number of electrons are consumed and produced.

5. Add together half reactions.

6. Clean up. Combine identical substances and reduce coefficients to the lowest terms.

7. CHECK! Atom and charge must balance.

APPENDIX

Standard Reduction (Electrode) Potentials at 25° C

Half-cell reaction	Eo (volts)
$F_2 + 2e \rightarrow 2F^-$	2.87
$Ce^{4+} + e \rightarrow Ce^{3+}$	1.61
$MnO_4^- + 8\ H^+ + 5e \rightarrow Mn^{2+} + 4H_2O$	1.51
$Cl_2 + 2e \rightarrow 2Cl$-	1.36
$Cr_2O_7^{2-} + 14\ H^+ + 6e \rightarrow 2Cr^{3+} + 7H_2O$	1.33
$O_2 + 4H^+ + 4e \rightarrow 2H_2O$	1.229
$Br_2 + 2e \rightarrow 2Br^-$	1.08
NO_3- $+ 4H^+ + 3e \rightarrow NO + 2H_2O$	0.96
$2Hg^{2+} + 2e \rightarrow Hg_2^{2+}$	0.920
$Hg^{2+} + 2e \rightarrow Hg$	0.855
$O_2 + 4\ H^+\ (10^{-7}\ M) + 4e \rightarrow 2H_2O$	0.82
$Ag^+ + e \rightarrow Ag$	0.799
$Hg_2^{2+} + 2e \rightarrow 2Hg$	0.789
$Fe^{3+} + e \rightarrow Fe^{2+}$	0.771
$I_2 + 2e \rightarrow 2I^-$	0.535
$Fe(CN)_6^{3-} + e \rightarrow Fe(CN)_4^{4-}$	0.48
$Cu^{2+} + 2e \rightarrow Cu$	0.337
$Cu^{2+} + e \rightarrow Cu^+$	0.153
$S + 2H^+ + 2e \rightarrow H_2S$	0.14
$2H^+ + 2e \rightarrow H_2$	0.0000
$Pb^{2+} + 2e \rightarrow Pb$	-0.126
$Sn^{2+} + 2e \rightarrow Sn$	-0.14
$Ni^{2+} + 2e \rightarrow Ni$	-0.25
$Co^{2+} + 2e \rightarrow Co$	-0.28
$Cd^{2+} + 2e \rightarrow Cd$	-0.403
$Cr^{3+} + e \rightarrow Cr^{2+}$	-0.41
$2H_2O + 2e \rightarrow H_2 + 2OH^-\ (10^{-7}\ M)$	-0.41
$Fe^{2+} + 2e \rightarrow Fe$	-0.44
$Cr^{3+} + 3e \rightarrow Cr$	-0.74
$Zn^{2+} + 2e \rightarrow Zn$	-0.763
$2H_2O + 2e \rightarrow H_2 + 2OH^-$	-0.83
$Mn^{2+} + 2e \rightarrow Mn$	-1.18
$Al^{3+} + 3e \rightarrow Al$	-1.66
$Mg^{2+} + 2e \rightarrow Mg$	-2.37
$Na^+ + e \rightarrow Na$	-2.714
$K^+ + e \rightarrow K$	-2.925
$Li^+ + e \rightarrow Li$	-3.045