Chapter 19 Electrochemistry Math Summary

Relating Standard Cell Potential to Standard Half Cell Potentials
\[ E^{\circ}_{\text{cell}} = E^{\circ}_{\text{oxidation}} + E^{\circ}_{\text{reduction}} \] (standard conditions assume 1.0 M concentrations)

Relating Half Cell Potentials when Written in Opposite Directions
\[ E^{\circ}_{\text{ox}} = -E^{\circ}_{\text{red}} \] for half reactions written in opposite directions

Relating Standard Cell Potentials to \( \Delta G \)
\[ \Delta G^{\circ} = -nFE^{\circ}_{\text{cell}} \] (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
\[ E_{\text{cell}} = E^{\circ}_{\text{cell}} - [0.0592/n] \log Q \] (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
\[ E_{\text{cell}} = -[0.0592/n] \log Q \] 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
\[ \text{moles of electrons} = \frac{[\text{current (A)} \times \text{time (sec)}]}{96,500} \] for electrolysis, moles, current, and time are related.
- rearranged: \[ \text{time (sec)} = \frac{(\text{moles of electrons})(96500)}{\text{current (in A)}} \]
  - Note: 3600 sec/hour
  - so time (hours) = (moles of electrons)(26.8)/current (in A)

Electrochemistry-Related Units
- \( C = \) Coulomb = quantity of electrical charge = \( 6.24 \times 10^{18} \) electrons
- 1 mole of electrons = 96,500 C
- \( A = \) amp = rate of charge flow per time = C/sec
- \( V = \) volt = electrical power/force/strength = J/C
- \( F = \) Faraday = \( \frac{96,500C}{\text{mole e}^-} = \frac{96.5 \text{ kJ}}{\text{mole e}^- \times V} \)
Assigning Oxidation Numbers (See Section 4.9)

Use these rules in order.

The sum of all oxidation numbers of all elements = charge on substance.

<table>
<thead>
<tr>
<th>Rule</th>
<th>Oxidation Number:</th>
<th>Examples:</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Atoms in their elemental state</td>
<td>= 0</td>
</tr>
<tr>
<td>2.</td>
<td>Monatomic ions</td>
<td>= charge</td>
</tr>
</tbody>
</table>

IN COMPOUNDS

3. Group 1A | = +1 | NaCl, KNO₃ |
4. Group 2A | = +2 | MgO |
5. Fluorine | = -1 | HF, ClF |
6. Hydrogen | = +1 | H₂O |
7. Oxygen | = -2 | SO₂, HClO₄ |
8. Group 7A (Halogen family) | = -1 | HCl |
9. Group 6A (Oxygen family) | = -2 | PbS₂ |

The sum of all oxidation numbers of all elements = charge on substance.

Key: For anything else, (or for a group 7A or group 6A in the presence of higher priority atoms), set it’s oxidation number = “x”, and solve for “x” such that the ox. #'s = actual charge.

Balancing Redox: Simple Cases where all Reactants and Products are Provides

1. Identify oxidation numbers for redox actors
2. Set coefficients for them so that the **#e’s released = #e’s accepted**
   - focus completely on the atoms whose oxidation numbers change
3. Then balance any redox spectators
4. Check at the end to make sure:
   - Charges balance
   - Atoms balance

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<table>
<thead>
<tr>
<th>Half-cell reaction</th>
<th>E₀ (volts)</th>
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<th>E₀ (volts)</th>
</tr>
</thead>
<tbody>
<tr>
<td>F₂ + 2e → 2F⁻</td>
<td>2.87</td>
<td>Pb²⁺ + 2e → Pb</td>
<td>-0.126</td>
</tr>
<tr>
<td>Ce⁴⁺ + e → Ce³⁺</td>
<td>1.61</td>
<td>Sn²⁻ + 2e → Sn</td>
<td>-0.136</td>
</tr>
<tr>
<td>MnO₄⁻ + 8 H⁺ + 5e → Mn²⁺ + 4H₂O</td>
<td>1.507</td>
<td>Ni²⁺ + 2e → Ni</td>
<td>-0.257</td>
</tr>
<tr>
<td>Cl₂ + 2e → 2Cl⁻</td>
<td>1.36</td>
<td>Co²⁺ + 2e → Co</td>
<td>-0.277</td>
</tr>
<tr>
<td>Cr₂O₇²⁻ + 14 H⁺ + 6e → 2Cr³⁺ + 7H₂O</td>
<td>1.33</td>
<td>Fe²⁺ + 2e → Fe</td>
<td>-0.447</td>
</tr>
<tr>
<td>O₂ + 4H⁺ + 4e → 2H₂O</td>
<td>1.229</td>
<td>Cr³⁺ + 3e → Cr</td>
<td>-0.74</td>
</tr>
<tr>
<td>Br₂ + 2e → 2Br⁻</td>
<td>1.066</td>
<td>Zn²⁺ + 2e → Zn</td>
<td>-0.7618</td>
</tr>
<tr>
<td>Ag⁺ + e → Ag</td>
<td>0.7996</td>
<td>2H₂O + 2e → H₂ + 2OH⁻</td>
<td>-0.8277</td>
</tr>
<tr>
<td>Fe³⁺ + e → Fe²⁺</td>
<td>0.5355</td>
<td>Al³⁺ + 3e → Al</td>
<td>-1.662</td>
</tr>
<tr>
<td>I₂ + 2e → 2I⁻</td>
<td>0.48</td>
<td>Mg²⁺ + 2e → Mg</td>
<td>-2.37</td>
</tr>
<tr>
<td>Cu²⁺ + 2e → Cu</td>
<td>0.3419</td>
<td>Na⁺ + e → Na</td>
<td>-2.71</td>
</tr>
<tr>
<td>2H⁺ + 2e → H₂</td>
<td>0.0000</td>
<td>K⁺ + e → K</td>
<td>-2.95</td>
</tr>
<tr>
<td>Cu⁺ + e → Cu⁺</td>
<td>0.153</td>
<td>Li⁺ + e → Li</td>
<td>-3.05</td>
</tr>
</tbody>
</table>