Chemistry 117
Problem Set 1

This problem set is due to the box outside 210A Noyes no later than 2:30 p.m. on Jan 18, 2017.

1. Do the following problems in Bard and Faulkner: 1.5, 1.6, 2.1a, 2.3.

2. Consider a fuel cell based on the coupling of an ethanol anode to an oxygen cathode. Assume that complete oxidation of the ethanol occurs and that an acidic electrolyte (Nafion) is employed. Thus, the anode half-cell can be written as:

$$CH_3CH_2OH + 3H_2O \rightarrow \text{products}$$

While the cathode half-cell would be:

$$O_2 + 4H^+ + 4e^- \rightarrow 2H_2O$$

a) If both reactions go to completion, this cell will produce ΔG = -1324 kJ/mol of ethanol. What is the largest open-circuit potential that one might observe from a direct ethanol fuel cell under standard conditions?
b) A direct ethanol cell operating at 110 °C produces an output of 0.5 V and 200 mA/cm^2. If this result is purely due to activation kinetic overpotential losses (i.e., no resistive or mass-transport losses), what is the effective net self-exchange current (i_0) for this cell?
c) If 400 mV of overpotential can be ascribed to the oxygen electrode under the conditions noted in part (b), what is the overpotential loss associated with the ethanol electrode and what is the effective charge-transfer resistance for this electrode at the current-voltage point noted in part (b)?

3. Another method of utilizing ethanol in a fuel cell is to first steam reform the ethanol to form H_2 and CO_2, followed by processing the hydrogen in a fuel cell. (Steam reforming is an endothermic process that runs at about 80% efficiency.) A good hydrogen fuel cell can produce 1 A/cm^2 at 0.5 V. How would this approach compare to the direct ethanol cell? That is, consider the consumption of 10 g of ethanol in both cases and calculate an efficiency percentage for electrical energy over chemical free energy.