ME 446.671 Fuel Cell Science and Technology

Midterm Exam

2007 Apr 19 14:30~15:45

1. [18 pts] Explain following terms.

a) Triple phase boundary

b) Standard electrode potentials

c) Activation energy

d) Exchange current density

e) Electroosmotic drag

f) Limiting current density

2. [20 pts] A hydrogen-oxygen fuel cell is operating under STP condition using hydrogen and air. The stoichiometric number of hydrogen and air is 1.1 and 2.0 respectively. At this condition, the fuel cell exhibits following characteristic.

$$V\ [V] = 1.2 - 0.6j\ [A/cm^2]$$

A compressor provides air to the fuel cell at the given flow rate. The power consumed by the compressor may be expressed as,

$$P\ [W/cm^2] = 0.3 * p\ [atm] * j\ [A/cm^2]$$

Here, p and j denote the pressure of air and current density of the fuel cell. Answer the following questions

(a) Find the maximum power output from the fuel cell combined with the compressor.

(b) Repeat (a) if the air is provided at 3 atm. (you should consider the voltage change of the fuel cell. For simplicity, consider only the Nernst effect)

(c) Find the efficiency of the fuel cell system (combined with compressor) for the condition described in (a) (say, at maximum power output of the fuel cell). Use enthalpy for hydrogen oxygen reaction as 286kJ/mol.

3. [21 pts] Bultler-Volmer equation has several simplified forms. Describe validity and usage of the following simplified equations.

a) Linearized BV equation

b) Tafel equation.

c) $$j_T = j_0\left[\exp\left\{\frac{\alpha F\eta}{RT}\right\} - \exp\left\{\frac{(1-\alpha)F\eta}{RT}\right\}\right]\frac{C_R^*}{C_R^0}$$

4. [20 pts] Consider a PEM fuel cell operating at 0.8A/cm^2 and 70C. Hydrogen gas at 90C and 80% relative humidity is provided to the fuel cell at the rate of 8 A. The fuel cell area is 8cm^2 and the drag ratio of water molecules/hydrogen, α is 0.8. Find the water activity of the hydrogen exhaust. Assume P=1 atm and assume the hydrogen exhaust exits at the fuel cell temperature, 70C.

5. [20 pts] A hydrogen-oxygen fuel cell at STP condition has the IV characteristic as shown in the figure. 2 A/cm^2 worth of hydrogen and 1 A/cm^2 worth of oxygen is provided to the fuel cell.
Now, we mix 20% volume percent ozone, O_3, to the oxygen (which is 80% now) with all other conditions are same. Sketch the IV curve for this case including as much detail as you can. Explain your IV curve to justify your answer.