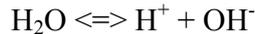


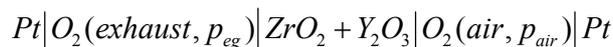
**MASSACHUSETTS INSTITUTE OF TECHNOLOGY**  
**FUNDAMENTALS OF ADVANCED ENERGY CONVERSION**  
**SPRING 04**  
**HOMEWORK IV**  
**DUE DATE, March 10, 2004**

1. For an overall reaction of

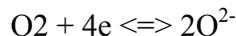


- (a) Use the Table 4.1 in the Lecture Note – Electrochemical Energy Conversion and Storage to define two half cell reactions for the above reaction and calculate the electrochemical potential of the reaction under standard conditions.
- (b) Calculate the molalities of  $\text{H}^+$  and  $\text{OH}^-$  in deionized water at 298K from the Gibbs free energy of reaction. Show calculation step by step.

2. An exhaust gas analyzer uses an electrochemical solid state cell (sensor) to measure oxygen concentrations in the exhaust. This cell consists of a solid-state electrolyte zirconium dioxide ( $\text{ZrO}_2$ ) with yttria ( $\text{Y}_2\text{O}_3$ ) that provides oxygen ion conduction in the cell, and Pt electrodes used for anode and cathode, depicted as,



The electrode reaction that occurs at high temperature at both the anode-electrolyte and cathode-electrolyte interfaces is



- (a) Please derive the governing equation for the cell potential as a function of pressures,  $P_{\text{eg}}$  and  $P_{\text{air}}$ .
- (b) What would the cell voltage be when the partial pressure of oxygen in the exhaust gas is 0.02atm?

3. Consider an electrochemical cell with different concentration of aqueous  $\text{CuCl}_2$  solutions in each 1/2 cell. 3.5 molal  $\text{CuCl}_2$  on one side and 1 molal  $\text{CuCl}_2$  solution on the other side separated by an ion conducting membrane permeable only to  $\text{Cu}^{+2}$  and  $\text{Cl}^{-1}$  ions. The electrodes are Pt coated with a thin film of copper metal.

- (a) Initially will the cell produce a current against a resistive load? Explain.
- (b) What is the maximum amount of work that such a cell would produce?
- (c) What happens to the concentrations of ions in the cell after a period of time?
- (d) Is there a way that you could modify this cell to determine the mean ionic activity of  $\text{CuCl}_2$  as a function of concentration? (hint- Consider coupling the cell to a standard hydrogen electrode via a salt bridge).

***The molality is the number of moles of solute present in 1000 grams of water while molarity is the number of moles of solute present in one liter of water. Mole fraction,***

$$X_i = \frac{\text{molality}}{\text{molality} + 1000/18} . \text{ State all assumptions made in answering questions 1-3.}$$