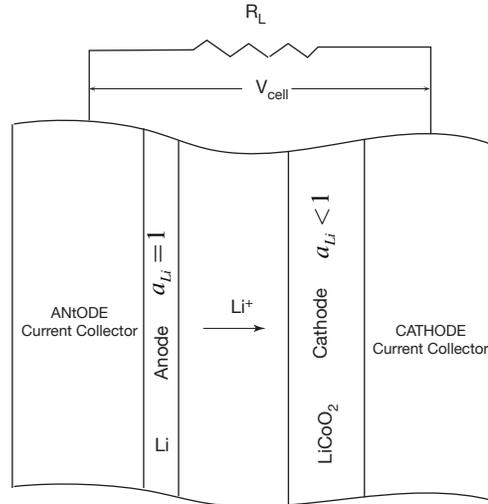


HW Exam on Electrochemistry (due Monday Nov 16, 2020)

Cell Architecture

1. The sketch of a Li ion battery is shown below



- On this figure write down the reactions at the anode and the cathode interface.
- If you were to measure the cell voltage with a voltmeter which terminal will be the positive electrode.

2. Write down the equation that relates the chemical potential of Li to its activity in a specific state.

3. Show that the Nernst Potential for a Li⁺ battery is given by

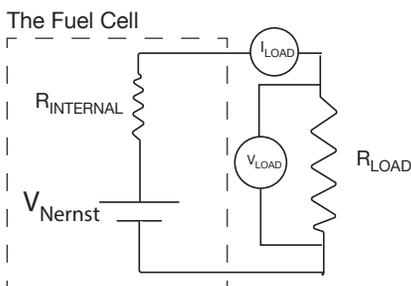
$$\Delta V_{OCV} = \frac{RT}{F} \ln \frac{a_A^{Li}}{a_V^{Li}} \quad (1)$$

Here a_A^{Li} is the activity of Li in the anode material, and a_C^{Li} in the cathode. Please state the assumption in your analysis with care and specificity.

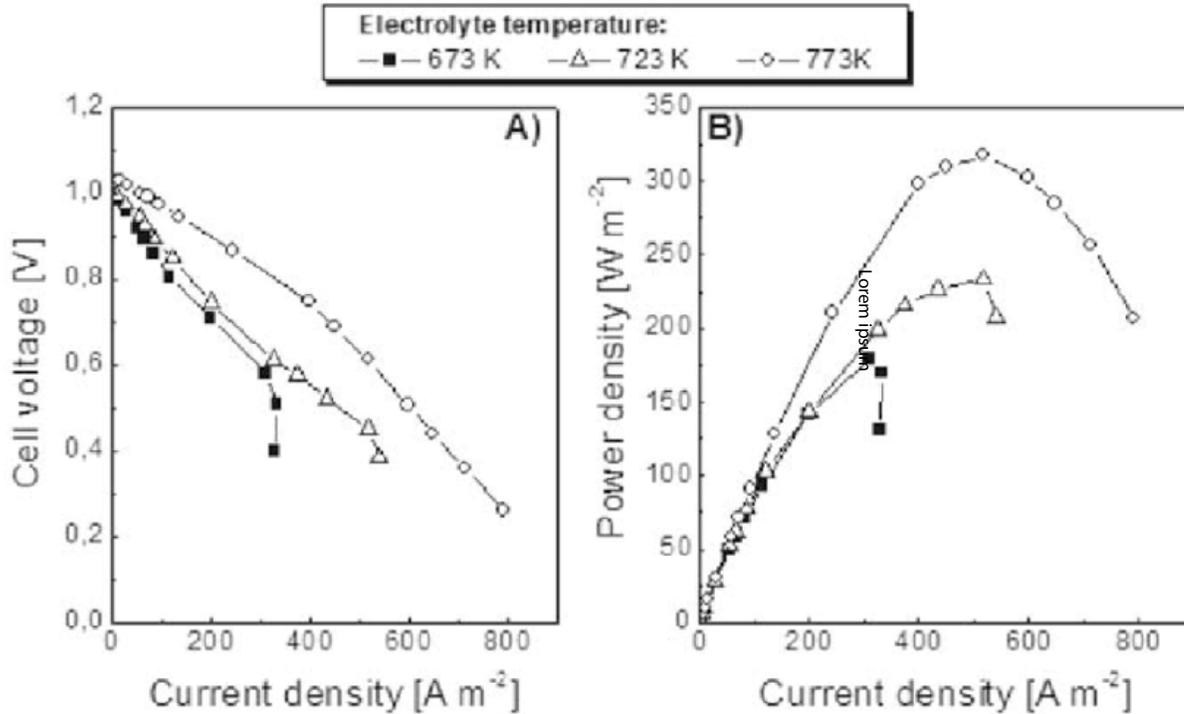
- What is the main advantage and the main disadvantage of using pure lithium metal as the anode material.

Performance Parameters: Cell Voltage and Power Density

4. The equivalent circuit for a fuel cell with an electrical load is shown below (it neglects interface resistance)



The response of a fuel cell (cell voltage and power) are shown below



(a) Point to the Nernst potential in the figure on the left.

(b) Justify the nearly straight line with a negative slope for the figure on the left. What is the significance of the slope of these lines.

(c) What is the significance of the maximum in the curve on the right. How can the position of the maximum be analyzed to yield the internal resistance in the equivalent circuit.

(d) Compare the results for the internal resistance from the two sets of data.

Properties of the Electrolyte in an Solid Oxide Fuel Cell

5. Comment on the name “SOFC” for a cell that uses hydrogen as a fuel; comment on each word in the name.

6. Ytria doped zirconia is preferred electrolyte in SOFCs. What is the significance of doping with Y_2O_3 ?

7. Instead of 7. Instead of Y_2O_3 it is also possible to dope with CaO (calcium oxide). Assuming that both dopants behave in a similar manner. If a certain conductivity is achieved for 8 mol% yttria, what would be the equivalent CaO that would be needed to achieve the same conductivity for oxygen ions. Show how the charge balance is achieved in the case of doping with CaO (see the notes for the case of Y_2O_3).

8. Can you comment on the possible reasons why yttria is chosen over calcium oxide? Feel free to speculate.

Sintering of the Zirconia Electrolyte

9. The yttria doped zirconia is prepared from powders by the sintering process. (The electrolyte must be hermetic so that hydrogen and oxygen gases do not travel across and “burn”.)

It is generally discovered that the sintering rate, which depends on the diffusion coefficient or the species, is not influenced by the yttrium content. Why is that while the fuel cell function does depend on the yttria content, sintering rate does not?