11/29/2019

Practice HW3 – Electrochemistry, Fuel Cells, Ionic Diffusion

3.1 Please see notes on Li+ batteries that consider the transport properties and their relationship of the energy density to the thickness of the anodes (pp 24-31 in the notes on Li+ batteries posted on the website). Derive Eq. (18) from first principles.

3.2 Please see note on Li+ batteries that consider a failure mechanism related to volume expansion and contraction in the anode (pp39-45 in the notes posted on the website, but also attached to this brief). Explain the graph sketched in Fig. 11 in these notes. Derive an expression for the critical particle size.

3.3 Define electrochemical potential and show its application to derive the Nernst potential for fuel cells.

3.4 Assume the internal resistance of the cell (arising from ionic conductivity of the electrolyte) to be one tenth of the resistive load on the fuel cell. Sketch and derive the curve for the power delivered as a function of the current drawn from the fuel cell. Assume the specific conductivity of the electrolyte to be 10 mS cm^{-1} (at the temperature of operation) and assume electrolyte to have a thickness of 100 μm, and the total surface area of the fuel cell to be 0.1 m^2. Assume the Nernst potential to be 2.3 V.

3.5 Calculate the activation energy for the diffusion of oxygen ions in 8.5 mol% yttria doped zirconia, from the data given in Badwal, as attached herewith.

3.6 Derive the equation for the specific conductivity of ionically conducting electrolyte as given in the notes on diffusion.

3.7 Show whether or not the diffusivity data for oxygen ions is consistent with the specific conductivity data as given in the attachments. Consider just one temperature (which you may assume) for your calculations.