1. Consider the below electrochemical reactions:

$$Zn + 2OH^- \rightarrow Zn(OH)_2 + 2e^-$$

$$NiOOH + H_2O + e^- \rightarrow Ni(OH)_2 + OH^-$$

   Refer to section 3.8 of the book and calculate the following:

   (a) The difference in potential across the cell that corresponds to a current density of 1000 A/m^2.

   (b) The discharge current that corresponds to a cell voltage of 1.3 Volts.

   (c) The discharge current that corresponds to a cell voltage of 2.0 Volts.

   Your calculations must be performed in MATLAB. All the data required is available in section 3.8 of the book.

2. Hydrogen gassing can be a serious problem for lead-acid batteries. Consider two reactions on the negative electrode: The desired reaction for charging:

$$PbSO_4 + 2e^- \rightarrow Pb + SO_4^{2-}$$

   and an undesired side reaction:

$$2H^+ + 2e^- \rightarrow H_2$$

   Given:

$$U^{\theta}_{PbSO_4} = -0.356 \text{ V}$$

$$U^{\theta}_{H_2} = 0 \text{ V}$$

   (a) The exchange-current densities for the two reactions are:

$$i_{o,PbSO_4} = 100 \text{ A/m}^2, \quad i_{o,H_2} = 6.6 \times 10^{-10} \text{ A/m}^2$$

   (The exchange-current density for the hydrogen reaction is on pure lead.) Calculate the current density for each reaction if the electrode is held at a potential of 0.44 V relative to a hydrogen reference electrode. The temperature is 25°C, and the transfer coefficients are 0.5.

   (b) With Sb impurity in the lead, the exchange-current density of the hydrogen reaction increases to 3.7×10^{-4} A/m^2. Repeat the calculation of part (a) in the presence of antimony. Assuming that all impurities cannot be eliminated, what implications do these results have for the operation of the battery?

Reference Text:

Electrochemical Engineering 1st Edition by Thomas F. Fuller (Author), John N. Harb (Author), John Wiley and Sons, 2018.