Issued: Sept. 28, 2015
Due: Oct. 8, 2015

ECHE 381/480: Electrochemical Engineering Professor Landau

Problem Set #3: Ionic Transport

1. Two parallel plate copper electrodes are immersed in 0.1 M $CuSO_4$ electrolyte supported by 1 M H_2SO_4. Each electrode is 4 cm^2 in area and the inter-electrode gap is 0.5 cm. Convection provides a uniform boundary layer thickness of 0.1 mm.

   a) Assuming that the only significant potential drop is ohmic (neglecting concentration variations and kinetic limitations), estimate the voltage required to pass a current of 40 mA. (Assume complete dissociation of H_2SO_4 to H^+ and $SO_4^=$ although this is not likely to be true).

   b) Sketch, schematically, the concentration profiles of all species present: Cu^{++}, H^+, $SO_4^=$. For simplicity assume again complete dissociation of H_2SO_4

   c) Determine quantitatively the concentration of all species at the electrodes.

   d) Repeat part (c) if the current density is raised to 200 mA.

   e) What is the limiting current for the system?

   f) Can you estimate the conductivity of the solution and the IR drop?

   g) Repeat parts (e) and (f) if the acid was completely removed.

2. Gold is plated out of potassium gold cyanide complex solution ($KAu(CN)_2$) of about 1 troy ounce per gallon, supported by 15 g/L monosodium phosphate and 20 g/L dipotassium phosphate. This solution yields a pH of about neutral (6.5-7.5).

   a) Considering that gold is tied down to a negative ion which does not dissociate to any appreciable extent, how does the gold get to the cathode and plate out?

   b) Estimate the transport number of gold in this electrolyte

   c) What is the limiting current, assuming a boundary layer of 0.1 mm.

3. a) What is the electric field in a cell where a current of 1 A passes between two 50 cm^2 electrodes, placed 0.5 cm apart. The electrolyte consists of 0.05 M KOH.

   b) What would be the voltage between the electrodes.

   c) How would your answers change if we added KOH so that the electrolyte concentration is now 1 M

   Ignore mass transport resistance and electrode kinetics limitations (however, you should consider the electrode reactions).