Assignment (combined between this and the prior week’s activity; due Thursday, May 2, 2019 at the start of class) (You must show your work for credit on all problems.)

Because these hands-on discussion sections are inquiry based, sometimes you and your lab partner(s) may deviate from the planned laboratory protocol. However, we expect that you will complete at least a portion of all major activities for each protocol. (For this time only, if you do not have the data required to answer the questions and/or perform the analyses below, please seek out a classmate who is willing to share his/her data and note that on your assignment.)

(1) Using data that you obtained during the lab activity from last week (Lab #2), do the following. Assume that the concentration of ferrocyanide (Fe\(^{II}\)(CN\(_6\))\(^4^-\)) was 10 mM, ferricyanide (Fe\(^{III}\)(CN\(_6\))\(^3^-\)) was 10 mM, and K\(_2\)SO\(_4\) was 500 mM, and that you used the button electrode (i.e. epoxied and polished carbon rod) for your measurements, with a well-defined geometric area of 7 mm\(^2\).
   a. Submit three plots made of your CV data in the absence of stirring (as \(I\) vs \(E\) (plot 1), \(E\) vs time (plot 2), and \(I\) vs time (plot 3)), where each plot includes the data taken for the various scan rates that you measured. If possible, use the EC-Lab software.
   b. Diffusion coefficients can be calculated from the peak currents measured in a cyclic voltammogram. Plot the peak current vs the square root of the scan rate for the anodic and cathodic processes of each cyclic voltammogram and use the Randles–Sevcik equation (Google it) and the slope of the data to calculate the diffusion coefficient for Fe\(^{II}\)(CN\(_6\))\(^4^-\) and Fe\(^{III}\)(CN\(_6\))\(^3^-\). Submit the plots as part of your answer.
   c. Explain what stirring did to mass transport of the redox-active species and in your answer indicate what terms dominated the flux toward the electrode (i.e. outside of the boundary layer) and at the electrode surface (i.e. within the boundary layer).

(2) Using data supplied to you on the course website related to the lab activity from this week (Lab #3), do the following for MnO\(_2\) deposited from an aqueous electrolyte onto FTO and electrochemically analyzed in dry propylene carbonate electrolyte.
   a. Answer the following by calculating the charge passed over 0 V to 0.3 V, averaging it for both sweep directions of the 2\(^{nd}\) CV sweeps at 10 mV/s: Determine the relative surface area (i.e. roughness factor) of the MnO\(_2\) electrode vs the bare FTO electrode (using non-faradaic capacitances) and the fraction of charge that is stored by faradaic intercalation of Li\(^+\) into MnO\(_2\) by comparing Li\(^+\) vs TBA\(^+\) data. Show work.
   b. Balance the redox reaction for electrodeposition of MnO\(_2\) from Mn(ClO\(_4\))\(_2\) and use it to determine the faradaic yield for MnO\(_2\) deposition using chronoamperometry data that you obtained during the lab activity and assuming that your average deposition rate was 0.1 \(\mu\)g/min. Show work.
   c. It is well-known that neutral SiO\(_x\) species can be electrodeposited by applying a cathodic bias of -200 mV vs RHE to a Pt electrode immersed in a slightly alkaline (pH \(\approx\) 11) aqueous solution containing soluble/charged SiO\(_x\)H\(_x\) species. This occurs even though the Pourbaix diagram of Si (Google it) suggests that no neutral SiO\(_x\) species are thermodynamically stable at this pH and potential. Explain how neutral SiO\(_x\) species can in fact be deposited on a Pt electrode under these conditions.