DEPARTMENT OF MATERIALS SCIENCE AND ENGINEERING
MASSACHUSETTS INSTITUTE OF TECHNOLOGY
CAMBRIDGE, MASSACHUSETTS 02139-4307

Donald R. Sadoway
Professor of Materials Chemistry
MacVicar Faculty Fellow

3.53 ELECTROCHEMICAL PROCESSING OF MATERIALS

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1. The concentration of cadmium and zinc ions in aqueous solution can be determined by chronopotentiometry at a mercury pool cathode. You analyze a solution containing 3.53 mM Cd^{2+}, no Zn^{2+} present. With a current of 33 mA you measure $\tau = 13$ s and $E_{\tau/4} = -0.403$ V vs NHE. You analyze a solution containing 3.53 mM Zn^{2+}, no Cd^{2+} present. With a current of 44 mA you measure $\tau = 8$ s and $E_{\tau/4} = -0.763$ V vs NHE.

33%

Your lab mate wishes to use chronopotentiometry to analyze the Cd^{2+} and Zn^{2+} concentrations of a solution containing both species. She sets the current at 55 mA and observes a double wave with a transition time of 2.5 s for the first wave and 10 s for the second wave. What are the concentrations of Cd^{2+} and Zn^{2+} in the solution?

2. The reduction of O_2 to HO_2^- at a gold electrode in O_2-saturated 0.1 *M* NaOH is characterized in Figure 9.3.8 in Bard & Faulkner, 2nd edition[¶].

33%

(a) Calculate the value of the rate constant, k_f, at an applied potential of 0.70 V.

(b) Calculate the value of the disk current at an applied potential of 0.3 V and a rotational frequency of 1111 rpm.

(continued on next page)

[¶] Figure 8.3.8 in Bard & Faulkner, 1st edition.

3. Sluyters and Oomen (Rec. Trav. Chim., 79, 1101 (1960)) employed electrochemical impedance spectroscopy (EIS) to characterize reactions occurring at amalgam electrodes. The results for the zinc and mercury systems are shown in Figure 10.4.5 in Bard & Faulkner, 2nd edition[§].

33%

(a) With reference to the **zinc** reaction, calculate each of the following or explain why data will not support the calculation:

i_o, the exchange current

C_d, the differential capacitance of the double layer.

(b) With reference to the **mercury** reaction, calculate each of the following or explain why the data will not support the calculation:

D, the diffusion coefficient of the mercurous ion, Hg_2^{2+};

R_Ω, the solution resistance.

In both systems, the amalgam electrode was a pool with a surface area measuring 1 cm^2.

Note that the frequencies on the plots of the impedance plane are values of f, not ω.

NOTE: The scales are incorrect in part (b) of the figure. Multiply by 0.40 to get the correct value of Z, e.g., where the graph gives 3 Ω, instead take this to be 1.20 Ω.

[§] Figure 9.5.8 in Bard & Faulkner, 1st edition.