CHEM-E4106 Electrochemistry D

Exam 22.02.2022

1. a) What does transport number describe? What is the reason for its existence?

   b) What is exchange current density? Why is it important to know it?

   c) During electrochemical reactions both ions and neutral species are transported in an electrochemical cell. Which forces affect their transfer?

   d) How do you observe charge transfer resistance in an impedance plot (Nyquist plot)?

   e) What is the role of each electrode in a three-electrode measurement set-up? What are the requirements for each electrode?

   f) What does Debye length describe? Which parameters affect it?

2. Formic acid can be used directly as a fuel in fuel cells. Its kinetic properties are studied in an aqueous electrolyte with a formic acid concentration of 0.5 mol/dm^3. The pK_a of formic acid is 3.74 at the temperature of 25^{o}C. Estimate the solution conductivity.

3. A Daniell Cell is a classic example of a galvanic cell that turns chemical energy into electrical energy. Inspired by the concept, a modified version has been constructed:

   Cu(s) | Cu(s) | $Cu(NO_3)_2$ (aq, 1.25 mol/dm^3) || $AgNO_3$ (aq, 1.5 mol/dm^3) | Ag(s) | Cu(s)

   What is the expected cell potential? You can assume that the Debye-Hückel equation holds for estimating the activities.

4. Hydrogen oxidation and reduction was studied with a PtIr electrode in 0.1 M KOH. The solution was stirred so vigorously that mass transfer can be neglected within the potential range used. The following current-overpotential data was obtained:

hydrogen oxidation		hydrogen reduction	
η / V	i / mA cm^{-2}	η / V	i / mA cm^{-2}
0.041312	10.82366601	-0.00798	1.043358628
0.037287	9.799764063	-0.00898	1.1218324
0.031856	8.28953131	-0.00984	1.295595753
0.027324	7.017295005	-0.01094	1.472784548
0.023764	6.061902573	-0.01146	1.566828514
0.021191	5.284984818	-0.01217	1.653243084
0.016189	4.04090644	-0.01306	1.836504255

Calculate the exchange current density and the charge transfer coefficient α for both the reacitons.

5. Analyze semi-quantitatively the impedance plots below. What quantities can you read from it? Explain the shape of the plot.