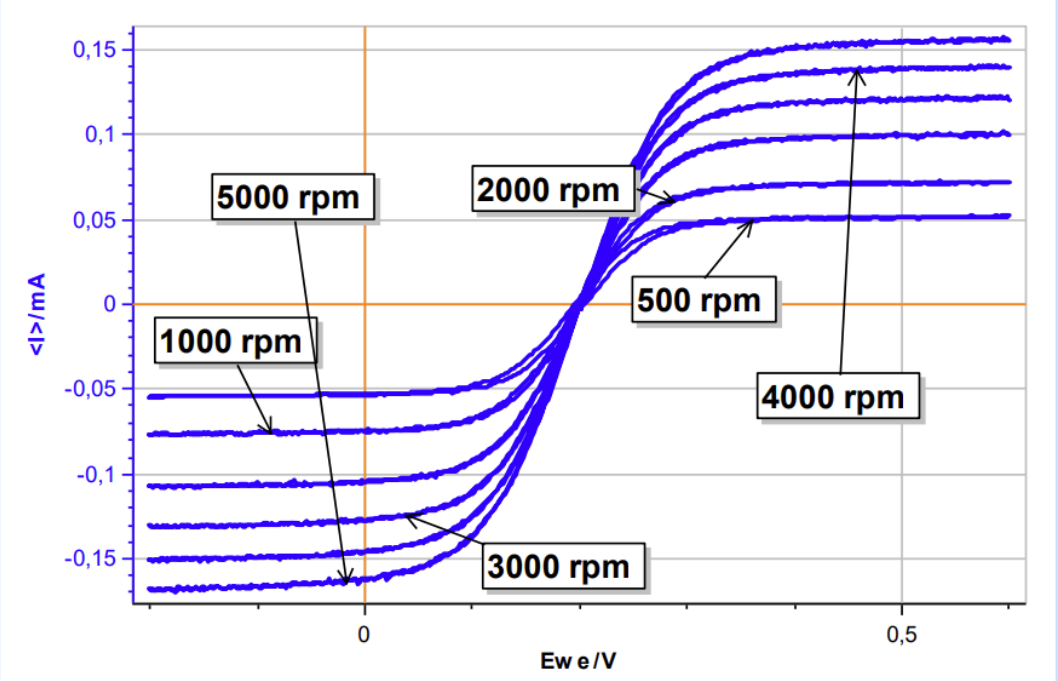
MSE-441 Exercise-7

Exercise 1:

Try to determine the diffusion coefficient for $[Fe(CN)_6]^{3-}$. The reduction of $[Fe(CN)_6]^{3-}$ is done in a RDE setup with a 2 mm diameter Pt disk. The concentration of $[Fe(CN)_6]^{3-}$ is 0.005 mol/L and $[Fe(CN)_6]^{4-}$ is 0.005 mol/L. The temperature and viscosity of the reactant solution is 20°C and 0.01 cm^2/s.



Solution:

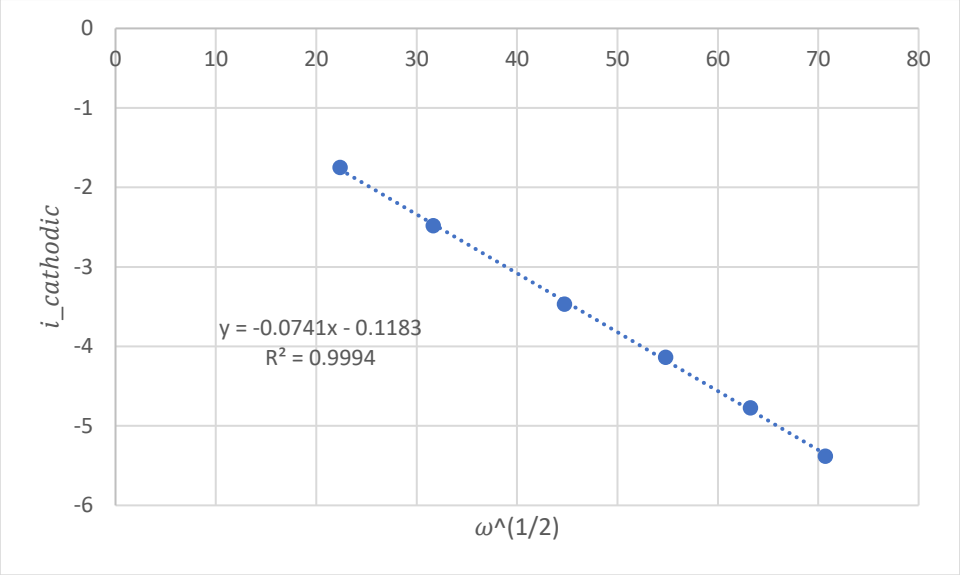
To determine the diffusion coefficient of $[Fe(CN)_6]^{3-}$, the cathodic Levich equation should be used, and $[Fe(CN)_6]^{3-}$ is reduced to $[Fe(CN)_6]^{4-}$:

$$i_{cathodic} = -0.620nF[O_{bulk}]D_o^{\frac{2}{3}}v^{-\frac{1}{6}}\omega^{\frac{1}{2}}$$

$$[Fe(CN)_6]^{3-} + e^- = [Fe(CN)_6]^{4-}$$

The diffusion limited current density at various rotation speed is extracted from the plot. Then plot $i_{cathodic}$ v.s. $\omega^{\frac{1}{2}}$:

rotation speed/rpm	500	1000	2000	3000	4000	5000
sqrt(rotation speed/rpm)	22.36068	31.62278	44.72136	54.77226	63.24555	70.71068
current/mA	-0.055	-0.078	-0.109	-0.13	-0.15	-0.169
current density/mA/cm2	-1.7507	-2.48282	-3.46958	-4.13803	-4.77465	-5.37944



The slope would be:

$$-0.620nF[O_{bulk}]D_o^{\frac{2}{3}}v^{-\frac{1}{6}} = -0.0741$$

Then to calculate the coefficient:

$$-0.620 \times 1 \times 96485 \left(\frac{C}{mol}\right) \times 0.005 \times \left(\frac{mol}{L}\right) D_o^{\frac{2}{3}} \left(0.01 \frac{cm^2}{s}\right)^{-\frac{1}{6}} = -0.0741 \left(\frac{mA}{cm^2} \cdot rpm^{\frac{1}{2}}\right)$$

$$1\ rpm = 0.1047\ rads/s$$

$$D_o^{\frac{2}{3}} = 3.55 \times 10^{-4} \left(\frac{cm^2}{s}\right)^{2/3}$$

$$D_o = 6.69 \times 10^{-6} \frac{cm^2}{s}$$