Chemistry 243 Winter Quarter 2017.
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Problem Set #3

Electrochemistry and Impedance Spectroscopy

1) Fick's Law Diffusion-limited Potential Step Measurements

a) For a diffusion-limited potential step, show that the Laplace transform for the concentration of the reactant C_O is given by:

$$C_0(x,s) = \frac{C_0^*}{s} - \frac{C_0^*}{s}\exp\left(-\sqrt{\frac{s}{D_0}}x\right)$$

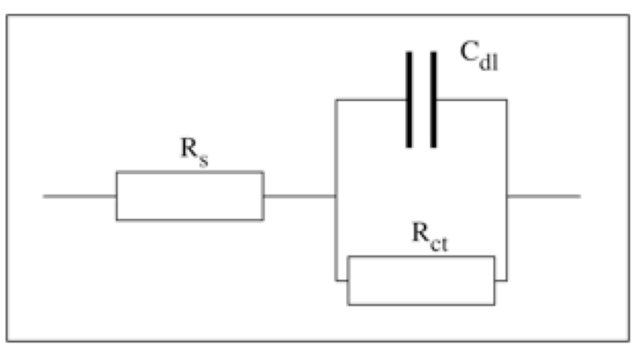
Where C^*_O is the bulk concentration and D_O is the Diffusion Constant.

b) Please use the inverse Laplace transform to find $C_O(x, t)$, and plot $C_O(x, t)$ vs. x for t = 1 ms, 100 ms, and 1 sec for the case where C^*_O = 1 mM and $D_O = 5 \times 10^{-6}$ cm^2 s^{-1}.

c) Please use Fick's first law in LaPlace space to get the Laplace transform of the current I(s). Then use the inverse LaPlace Transform to find I(t). This is called the Cottrell Equation.

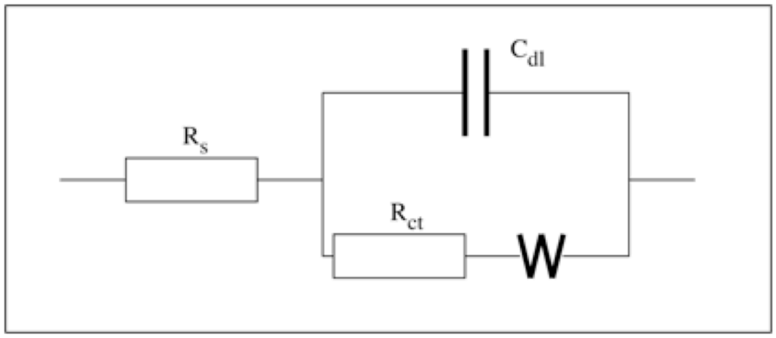
EC Impedance Measurements.

2) Generate a Nyquist Impedance Plot and Bode Impedance plots (both magnitude and phase) for an angular frequency range of 10^{-2} rad s^{-1} to 10^{8} rad s^{-1} for a charge transfer system with no diffusion effects (Randles Cell):



Where R_s = 1000 ohms, R_{ct} = 2000 ohms, and C_{dl} = 2.0 μF.

3) Generate a Nyquist Impedance Plot and Bode Impedance plots (both magnitude and phase) in a frequency range of 10^{-2} rad s^{-1} to 10^{8} rad s^{-1} for a charge transfer system with diffusion effects (Randles-Ershler Circuit):



Where R_S = 1000 ohms, R_{ct} = 2000 ohms, C_{dl} = 2.0 μF and σ = 1000 ohm $rad^{1/2}$ $s^{-1/2}$.