Assignment 2

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1 Question 1:

The equation for normalised sheath potential is:

$$\frac{d^2V}{d\eta^2} = \sqrt{\left(1 + \frac{2V}{M_{se}^2}\right)} - e^{-V} \tag{1}$$

The equation for the corresponding electric field is

$$\frac{dV}{d\eta} = \sqrt{2M_{se}^2\left(\sqrt{\left(1 + \frac{2V}{M_{se}^2}\right)} - 1\right) + 2e^{-V} + \epsilon^2 - 2} \tag{2}$$

For a neutral wall $M_{se}^2 = 1$

2 Question 2:

2.1 Bohm's approximation

For $V << 1$

$$\frac{d^2V}{d\eta^2} = V\left(1 - \frac{1}{M_{se}^2}\right) \tag{3}$$

and

$$\frac{dV}{d\eta} = \sqrt{\left(1 - \frac{1}{M_{se}^2}\right)V^2 + \epsilon^2} \tag{4}$$

For a neutral wall $M_{se}^2 = 1$, implying $d^2V/d\eta = 0$ and $dV/d\eta = \epsilon$

2.2 Child- Langmuir approximation:

For $V >> 1$

$$\frac{d^2V}{d\eta^2} = \frac{M_{se}}{\sqrt{2}}\frac{1}{\sqrt{V}} \tag{5}$$

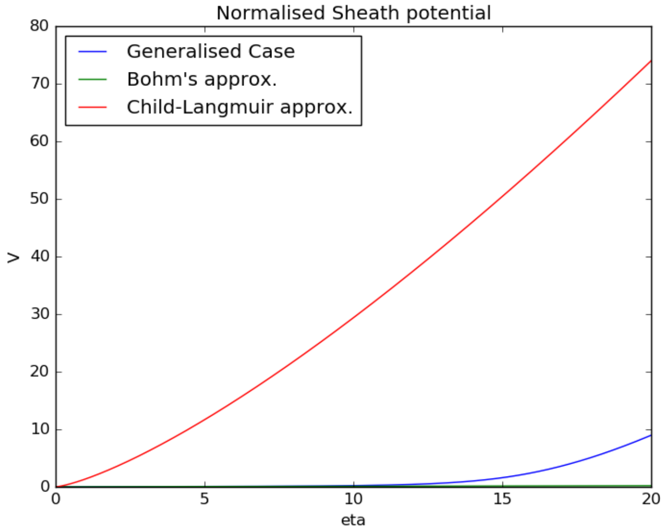
and

$$\frac{dV}{d\eta} = 2^{3/4}\sqrt{M_{se}}V^{1/4} \tag{6}$$

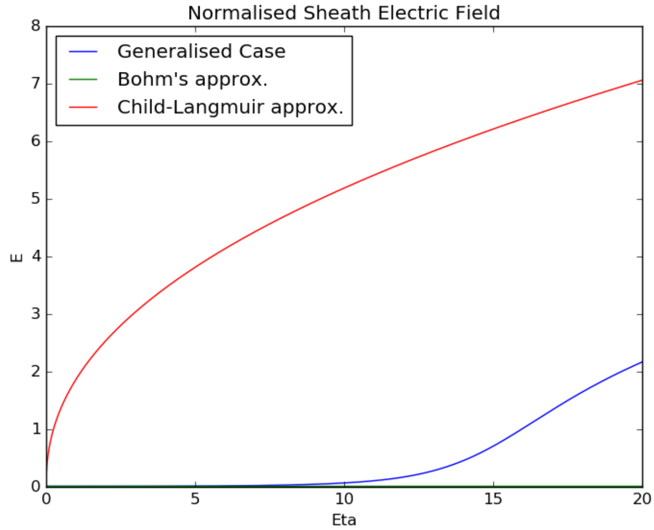
For a neutral wall $M_{se}^2 = 1$.

3 Question 3:

The plots of normalised sheath potential are shown below for the 3 cases. $\epsilon = 0.01$ has been used.



Plots of normalised electric field:



4 Question 4:

We checked the normalised thickness of sheath for $dV/d\eta = 0.1, 0.01, 0.001$, we get a normalised sheath thickness(η) of $7.63, 16.32, 33.83$ respectively. Refer code ($\Delta eta = 0.01$)

5 Question 5:

We checked the values of $dV/d\eta$ at wall for ϵ values of $0.1, 0.01, 0.001$. The results are $1.1268, 1.1224, 1223$ respectively. Thus se can see the the values are very near to 1 and tend to 1 as we decrease the value of ϵ

6 Question 6:

For electrode potential $= 1V$ sheath thickness(normalised) $= 14.29$
For electrode potential $= 10V$ sheath thickness(normalised) $= 21.14$
For electrode potential $= 100V$ sheath thickness(normalised) $= 47.04$
We see that for 1V and 10V, Bohm's approximation is always better than Child Langmuir approximation. For 100V, Child Langmuir approximation is better for $\eta > 46.98$ ($\Delta eta = 0.01$)