2010 I: QSA Exp

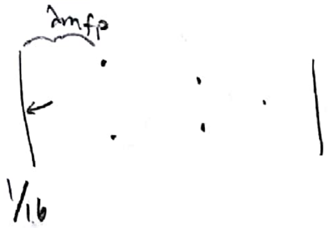
a.) From NRL Formulary page 39

$\sigma_e \sim 5\times10^{-15}\ cm^2$

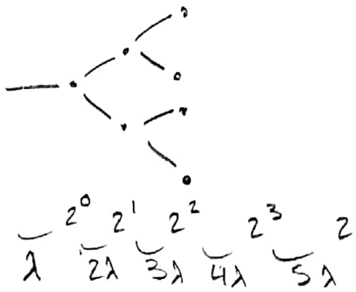
b.) $\lambda = \frac{1}{n\sigma}$ $n = \frac{N}{\pi r^2 d}$ $PV = NkT \Rightarrow P = nkT$

$\boxed{\lambda_{mfp} \approx \frac{kT}{P\sigma_e}}$ $\nu = \frac{v_{th}}{\lambda_{mfp}} = \left(\frac{kT}{m_e}\right)^{1/2}\frac{P\sigma_e}{kT} \Rightarrow \boxed{\nu = \frac{P\sigma_e}{(m_e kT)^{1/2}}}$

c.)



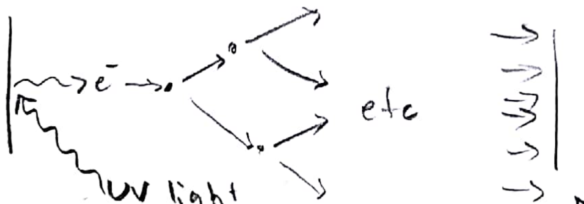
at least 16 neutrals must be ionized



$\boxed{d \gtrsim 5\lambda_{mfp}}$

d.) Assume that UV is used for photoelectric effect, then it must be aimed at the cathode so that the produced electrons can flow through the plasma to the anode.

e.)



the first current "bump" occurs when the original electrons reach the anode.

The original electrons also ionize neutrals, which then collide with the cathode to produce a second current bump.

The first bump occurs after a time $t_1 \approx \frac{5\lambda_{mfp}}{V_e}$. The ions move much slower $\left(\frac{V_{the}}{V_{thi}} \sim \sqrt{\frac{m_i}{m_e}}\right)$ so $t_2 \approx \frac{\lambda_{mfp}}{V_i}$

$F = ma \Rightarrow eE = m_e\ddot{x} \Rightarrow \dot{x} = \frac{e\frac{d\phi}{dx}}{m_e}t_{coll}$ ϕ' is known by operator: $\frac{\phi_0}{d}$

$V_{average} = \frac{e\phi'}{m_e}\left(\frac{t_{coll}}{2}\right) = \frac{e\phi_0}{m_e d}\frac{1}{2\nu} = V_e$ $V_i = \sqrt{\frac{m_i}{m_e}}\,V_e$

f.) Plasma density decay is contributed to by ambipolar diffusion to the walls, 2-body radiative recombination and 3-body recombination. The voltage required to quench the plasma is lower than the breakdown voltage because once the plasma is turned on sheaths are generated, which confines the electric field to a smaller region in which the electrons (and ions) are accelerated quicker.