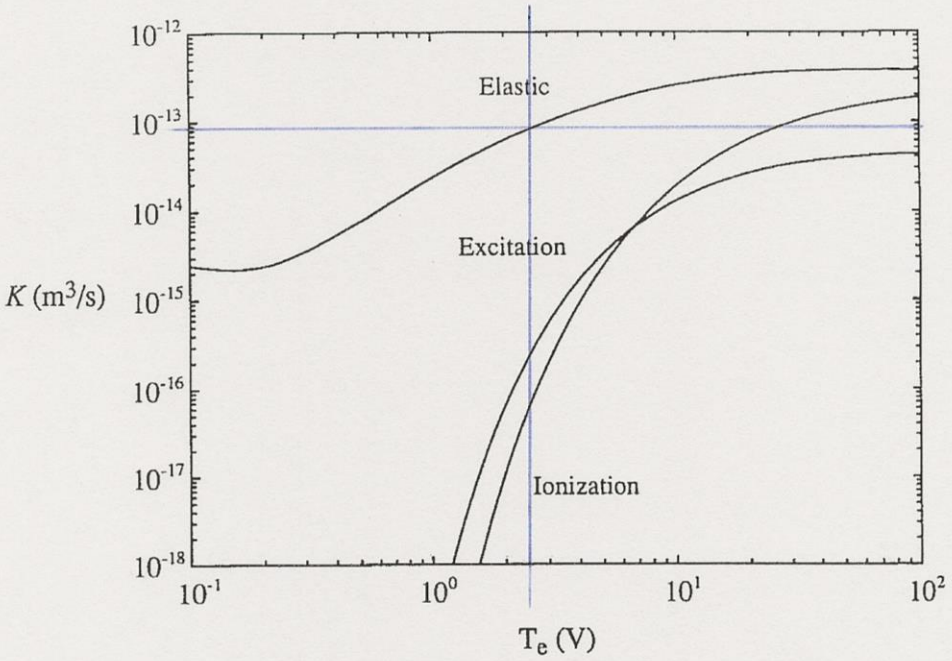
EE507 – Plasma Physics and Applications

Homework #7

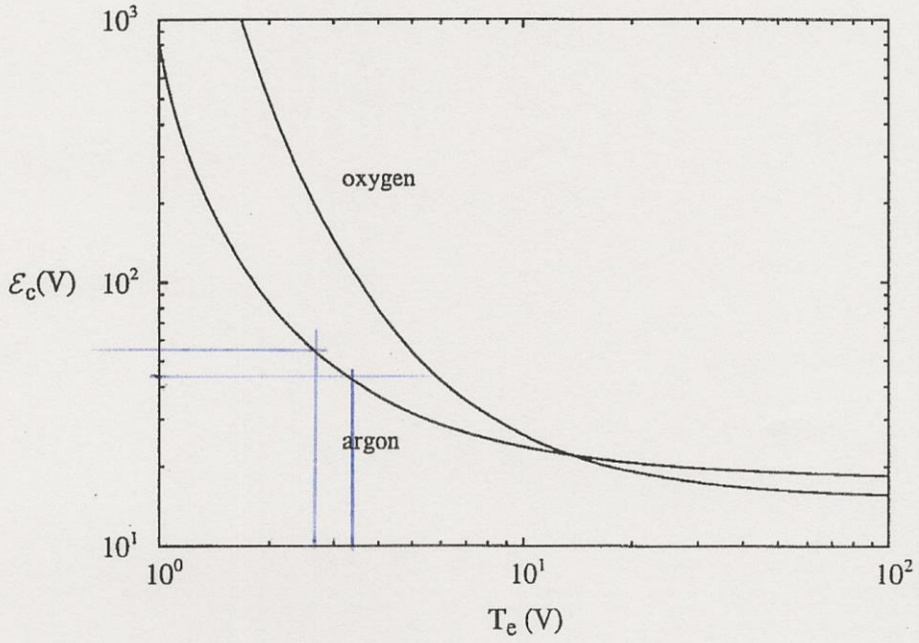
Consider a parallel plate RF discharge running with the following parameters:

- Pressure (p): 3 mTorr argon at 300K
- Distance between plates (l): 25 cm
- Area of the plates (A): 2000 cm^2
- Excitation frequency (f): 13.56 MHz
- RF current (I_{rf}): 50 mA

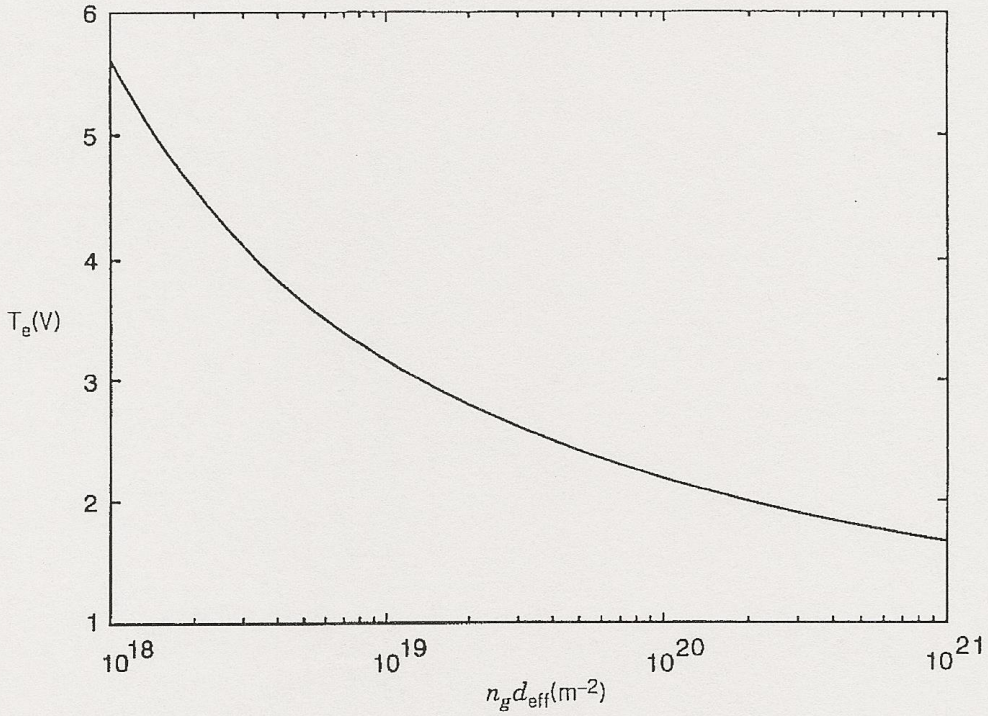
1. Calculate the ion mean free path and compare to the distance between plates. How do you expect the plasma profile to be between the plates? (Qualitatively)
2. Assuming that sheath thickness is of the order of 1 cm, use the corresponding graph below to estimate the electron temperature.
3. A crude analytical approximation to electron collisional ionization rate constant is $K_{iz}=K_{izo}\exp(-E_{iz}/T_e)$, where E_{iz} is the ionization energy and the preexponential factor is $K_{izo}= 5\text{x}10^{-14}$ m^3/s for argon. Using this approximation, estimate the value of the electron temperature using particle balance.
4. Calculate the Bohm velocity.
5. Using the corresponding graphs below, calculate the plasma density. Remember that most of the electron collisions are elastic.
6. Calculate the time-average power per unit area deposited by both ohmic and stochastic heating.
7. Calculate the average voltage across each sheath.
8. Calculate the total power absorbed.
9. Calculate the average thickness of the sheath. Is the result compatible with the initial assumptions?
10. What is the average kinetic energy per ion hitting the electrodes?



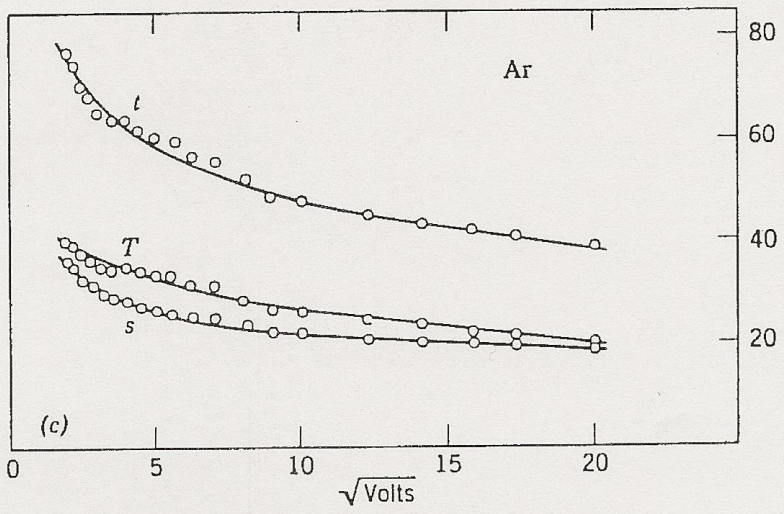
. Electron collision rate constants K_{iz}, K_{ex} and K_m versus T_e in argon gas ompiled by Vahedi, 1993).



Collisional energy loss per electron–ion pair created, $\mathcal{E}_c$, versus T_e in argon and oxygen (compiled by Vahedi, 1993).



T_e versus $n_g d_{eff}$ for Maxwellian electrons in argon.



Experimental values for elastic scattering (s), charge transfer (T), and the sum of the two mechanisms (t) for argon ions in their parent gases (McDaniel et al., 1993).