CHEMICAL ENGINEERING DEPARTMENT

ChE 234, Spring 2004

Principles of Plasma Processing

Midterm No. 1A

Profs. Chang and Chen Tuesday, May 4, 2004

1. For argon, the ionization probability can be approximated by the function

$$< \sigma v >_{ion} = \mathrm{e}^{-(a+b/T_{eV}^{c})} \ \mathrm{cm}^3/\mathrm{sec},$$

where a = 15.8, b = 17.7, and c = 0.91. The elastic collision rate can be approximated by

$$n_0 < \sigma v > = a T_e^b e^{-c/T_{eV}} \ \ \mathrm{MHz/mTorr},$$

where a = 12.5, b = –.036, and c = 3.85. About how many elastic collisions does an electron in a 3-eV plasma make, on the average, before it causes an ionization?

2. A 4-eV argon plasma has density 2×10^{10} cm^{-3} everywhere (except in the sheath) in a cubic container 10 cm on a side. A small sphere hangs by a wire at the center of the cube, and an electron current I_e is drawn to it by applying a positive voltage. As I_e is increased, the sheath drop at the wall must increase to repel more electrons, since electrons must now go the sphere. When essentially no electrons go to the wall, the flux of electrons to the sphere is balanced by the flux of ions to the walls, keeping the plasma neutral. If I_e is further increased, ambipolar fields must arise to drive out more ions, and the plasma is disturbed. What is the maximum value of I_e that can be drawn to the sphere without disturbing the plasma? [Hint: remember that the ions arrive at the sheath edge with velocity c_s, and that the density there is about half the plasma density.]