CHEMICAL ENGINEERING DEPARTMENT
ChE 234, Spring, 2004

Homework Assignment No. 1

PROF. F.F. CHEN

Assigned April 8, 2004 Due April 15, 2004

Note: The initial problems ask you to verify shortcut formulas given to you so that you do not have to take them on faith. Please work these out yourself and do not copy previous answers. You will be graded on effort.

1. Using the known value of Boltzmann's constant, show that a 1-eV plasma has a temperature of 11,600 K.
2. Starting from its definition in Eq. (II-5), show that the Debye length in cgs units is
$$\lambda_D = 740\sqrt{T_{eV}/n} \quad \text{cm}.$$
3. Starting from its definition in Eq. (II-8), show that the plasma frequency is given by
$$f_p = 9\sqrt{n_{12}} \quad \text{GHz},$$
where n_{12} is the density in units of 10^{12} cm^{-3}.
4. Starting from its definition in Eq. (II-11), show that the cyclotron frequency is
$$f_c = 2.8 \text{ MHz per Gauss}$$
where 1 G = 10^{-4} Tesla.
5. Electron Cyclotron Resonance (ECR) plasma sources operate at f = 2.45 GHz, the same frequency used for microwave ovens and some cordless phones. These sources operate with $\omega = \omega_c$. What magnetic field does this correspond to?
6. What is the ion acoustic speed in a 3-eV argon plasma? [This means that KT_e = 3 eV.]
7. Calculate the Larmor radius of an electron with perpendicular energy equal to the argon ionization threshold in an ECR reactor.
8. Starting from basic principles [not Eq. (III-8)], calculate the neutral density of Cl_2 molecules at 20°C and 1 mTorr pressure.
9. In a 10–mTorr argon plasma with $n = 10^{12}$ cm^{-3} and KT_e = 3.2 eV, what is the ionization rate (no. of ion-electron pairs created per cm^{-3} per sec)?
10. If the electric field in a 1–keV plasma is 1V/m, what is the current density? *Give units*.