PH631 Fall 2015

Electromagnetic Theory I

Homework #7 Due: Monday 11-23-2013

1. (*Based on Jackson Chpt 4*) Water vapor is a polar gas whose electric susceptibility depends on temperature. In class we discussed a model for the time-averaged dipole moment of a dipole p_0 that undergoes thermally-driven rotation in an external electric field **E**:

$$\langle \mathbf{p} \rangle = \frac{1}{3} p_0 \frac{p_0 \mathbf{E}}{k_b T} \qquad (1)$$

The table below summarizes experimental measurements of the relationship between polarization and electric field for water vapor ($\mathbf{P} = \varepsilon_0 \chi_e \mathbf{E}$).

T (K)	Pressure (cm Hg)	χ_e
393	56.49	400.2 x 10^{-5}
423	60.93	371.7 x 10^{-5}
453	65.34	348.8 x 10^{-5}
483	69.75	328.7 x 10^{-5}

a) The microscopic model (Eq. 1) predicts that the time-averaged dipole moment per water molecule will decrease as $1/T$. Check this prediction by graphing appropriate experimental quantities (for example, put $1/T$ on the x-axis).

b) Deduce a value for the permanent dipole moment of the H_2O molecule, p_0. (Express the dipole moment in *e*-angstrom, where *e* is the charge of the electron).

2. *(Based on Griffiths 4.33)*

A dielectric cube of side *a*, centered at the origin, carries a "frozen in" polarization $\mathbf{P} = k\mathbf{r}$, where *k* is a constant. Find all the bound charges, and check that they add up to zero.