Home Work #PYL102 Oct 19-10-2024

Due Date: Oct. 24, 2024

Q1. **Electronic polarization and SF6:** Because of its high dielectric strength, SF6 (sulfur hexafluoride) gas is widely used as an insulator and a dielectric in HV applications such as HV transformers, switches, circuit breakers, transmission lines, and even HV capacitors. The SF6 gas at 1 atm and at room temperature has a dielectric constant of 1.0015. The number of SF6 molecules per unit volume N can be found by the gas law, $P = (N/N_A)RT$. Calculate the electronic polarizability of the SF6 molecule. Assume that the overall polarizability of SF6 is due to electronic polarization.

Q2. **Ionic and electronic polarization**: Consider a CsBr crystal that has the CsCl unit cell crystal structure (one Cs+-Br_ pair per unit cell) with a lattice parameter (a) of 0.430 nm. The electronic polarizability of Cs+ and Br~ ions are 3.35×10^{-40} F m^2 and 4.5×10^{-40} F m^2, respectively, and the mean ionic polarizability per ion pair is 5.8×10^{-40} F m^2. What is the low-frequency dielectric constant and that at optical frequencies?

Q3. **Student microwaves mashed potatoes:** A microwave oven uses electromagnetic waves at 2.48 GHz to heat food by dielectric loss, that is, making use of ε'' of the food material, which normally has substantial water content. An undergraduate student microwaves 10 cm^3 of mashed potatoes in 60 seconds. The microwave generates an rms field of E_{rms} of 200 V cm^{-1} in mashed potatoes. At 2.48 GHz, mashed potatoes have $\varepsilon'' = 21$. Calculate the average power dissipated per cm^3 and also the total energy dissipated heating the food.

Q4. Conduction in gold Gold is in the same group as Cu and Ag. Assuming that each Au atom donates one conduction electron, calculate the drift mobility of the electrons in gold at 22 ^{0}C. What is the mean free path of the conduction electrons if their mean speed is 1.4×10^6 m s^{-1}?

Q5. **The Hall effect**: Consider a rectangular sample, of n-type semiconductor with a length L, width W, and thickness D. A current / is passed along L, perpendicular to the cross-sectional area WD. The face W x L is exposed to a magnetic field density B. A voltmeter is connected across the width, as shown in Figure, to read the Hall voltage V_H. Show that the Hall voltage recorded by the voltmeter is $V_H = IB / Den$.

Consider a 1-micron-thick strip of gold layer on an insulating substrate that is a candidate for a Hall probe sensor. If the current through the film is maintained at constant 100 mA, what is the magnetic field that can be recorded per μV of Hall voltage?