Q.1) Consider a pure Si crystal that has εr = 11.9.
a. What is the electronic polarizability due to valence electrons per Si atom (if one could portion the observed crystal polarization to individual atoms)?
b. Suppose that a Si crystal sample is electrode on opposite faces and has a voltage applied across it. By how much is the local field greater than the applied field?

From the density of the Si crystal, the number of Si atoms per unit volume, N, is given as 5 × 1028 m-3.

Q.2)

A). Amorphous selenium (a-Se) is a high resistivity semiconductor that has a density of approximately
4.3 g cm-3 and an atomic number and mass of 34 and 78.96 g/mol respectively. Its relative Permittivity at 1 kHz has been measured to be 6.7. Calculate the polarizability per Se atom in the structure.

B.) If the electronic polarizability of an isolated atom is given by

$$\alpha_e \approx 4\pi\varepsilon_o r_o^3$$

Where ro is the radius of the atom, then calculate the electronic polarizability of an isolated Se atom, which has r0= 0.12 nm, and compare your result with that for an atom in a-Se. Why is there a difference?

Q3)

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 Cl^- 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?

Q4)

NEARLY DEBYE RELAXATION There are some dielectric solids that exhibit nearly Debye relaxation. One example is the $La_{0.7}Sr_{0.3}MnO_3$ ceramic whose relaxation peak and Cole–Cole plots are similar to those shown in Figures 7.13b and 7.17,[10] especially in the high-frequency range past the resonance peak. $La_{0.7}Sr_{0.3}MnO_3$'s low frequency (ε_{rdc}) and high frequency ($\varepsilon_{r\infty}$) dielectric constants are 3.6 and 2.58, respectively, where *low* and *high* refer, respectively, to frequencies far below and above the Debye relaxation peak, *i.e.*, ε_{rdc} and $\varepsilon_{r\infty}$. The Debye loss peak occurs at 6 kHz. Calculate ε_r' and the dielectric loss factor $\tan\delta$ at 29 kHz.

Q5)

Consider a nonpolarized 100 nF capacitor design at 60 Hz operation. Note that there are three candidate dielectrics, as listed in Table 7Q11-1.

a. Calculate the volume of the 100 nF capacitor for each dielectric, given that they are to be used under low voltages and each dielectric has its minimum fabrication thickness. Which one has the smallest volume?

b. How is the volume affected if the capacitor is to be used at a 500 V application and the maximum field in the dielectric must be a factor of 2 less than the dielectric strength? Which one has the smallest volume?

	Polymer Film PET	**Ceramic TiO_2**	**High-*K* Ceramic ($BaTiO_3$ based)**
Name	Polyester	Polycrystalline titania	X7R
ε_r'	3.2	90	1800
$\tan\delta$	5×10^{-3}	4×10^{-4}	5×10^{-2}
$\mathcal{E}_{br}$ (kV cm^{-1})	150	50	100
Typical minimum thickness	1-2 μm	10 μm	10 μm