Colloquiums tasks for Dielectrics

The tasks are taken from the book "Understanding Solids…"

11.1   The plates on a parallel plate capacitor are separated by 0.1 mm and filled with air.
(a) What is the capacitance if the plates have an area of 1 cm^2?
(b) If the space between the plates is filled with a polyethylene sheet, with a relative permittivity of 2.3, what is the new capacitance?

11.2   A parallel plate capacitor is connected to a battery and acquires a charge of 200 μC on each plate. A polymer is inserted and the charge on the plates is now found to be 750 μC. What is the relative permittivity of the polymer?

11.4   The dipole moment of the molecule nitric oxide, NO, is 0.5 x 10^{-30} Cm. The N–O bond length is 0.115 nm.
(a) what is the charge on the atoms?
(b) Which atom is more positive?

11.19   The relevant value of piezoelectric coefficient, d, for a quartz is given as 2.3 pC N^{-1}. Calculate the polarization of a plate of dimension 10 cm x 5 cm x 0.5 mm when a mass of 0.5 kg is placed on it.

11.21   The semiprecious gemstone tourmaline, with an approximate formula $CaLi_2A_{l7}(OH)_4$-$(BO_3)_3Si_6O_{18}$, has a pyroelectric coefficient, π_i, of 4 x 10^{-6} Cm^{-2} K^{-1}. The unique polar axis is the crystallographic c axis. What is the change in polarization caused by a change of temperature of 100 °C?

11.22   The measured relative permittivity, ε_r, of a ceramic sample of $PbZrO_3$ as a function of temperature, T, is given in Table 11.3. Determine (a) the Curie temperature, T_c, and (b) the Curie constant, C, for this sample.

11.25   Zincite (zinc oxide, ZnO) has a hexagonal unit cell, with a_0 = 0.3250 nm, c_0 = 0.5207 nm and a unit cell volume of 47.63 x 10^{-27} m^3. The atom positions are:
Zn (1/3, 2/3, 0), (2/3, 1/3, 1/2)
O (1/3, 2/3, 0.389), (2/3, 1/3, 0.611).
There are two formula units of ZnO in the unit cell.
(a) Sketch the unit cell
(b) Estimate the maximum spontaneous polarization of ZnO, assuming that the structure is ionic. The positions for the tetrahedraholes in the ideal structure are: (1/3, 2/3, 0.375), (2/3, 1/3, 0.625)

11.29   (a) Calculate the dipole moment of a TiO_6 octahedron in $PbTiO_3$, with a very slightly distorted perovskite structure, in which a_0 = 0.3899 nm, c_0 = 0.4153 nm, tetragonal, assuming that the compound is fully ionic and that the Ti^{4+} ions are displaced by 0.030 nm along the c axis of the unit cell. (b) Determine the maximum spontaneous polarization under these conditions.

11.30   Most ceramics are electrical insulators. Describe the combination of factors that would allow a ceramic to be classified as a ferroelectric rather than just an

insulator.

11.31   Both silica glass and quartz, SiO_2, are composed of SiO_4 tetrahedra and neither material posses a centre of symmetry. Why is silica glass not a piezoelectric, whereas quartz is?

Table 11.3   Data for question 11.22

ε_r	130	142	166	222	360	420	472	556
$T/°C$	50	100	150	200	225	230	234	235

ε_r	775	3200	3000	2840	2440	1620	1240	840
$T/°C$	236	238	240	242	250	275	300	350