

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 cm²?
(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 0.5×10^{-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 CaLi₂A₁₇(OH)₄(BO₃)₃Si₆O₁₈, has a pyroelectric coefficient, π_i , of 4×10^{-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 PbZrO₃ 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 47.63×10^{-27} m³. The atom positions are:
Zn (1/3, 2/3, 0), (2/3, 1/3, 1/2)
O (1/3, 2/3, 0.38), (2/3, 1/3, 0.58).
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.
- 11.29 (a) Calculate the dipole moment of a TiO₆ octahedron in PbTiO₃, 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 Ti⁴⁺ 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 possesses 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
$T/^\circ\text{C}$	50	100	150	200	225	230	234	235
ϵ_r	775	3200	3000	2840	2440	1620	1240	840
$T/^\circ\text{C}$	236	238	240	242	250	275	300	350