Answer on Question #69083, Physics / Electromagnetism

A glass of relative permittivity 4 is kept in an external electric field of magnitude 102 Vm−1. Calculate the polarisation vector, molecular/atomic polarisability and the refractive index of the glass.

Solution:

Polarisation vector:

$\vec{P} = \chi\varepsilon_0\vec{E}$ (1), where χ is the electric susceptibility, ε_0=8.85×10^{-12} F/m, E is the magnitude of electric field

The relative permittivity of a medium ε_r is related to its electric susceptibility, χ:

$\varepsilon_r = 1 + \chi$ (2)

Of (2) $\Rightarrow$ $\chi = \varepsilon_r - 1$ (3)

Of (3) $\Rightarrow$ χ=4-1=3 (4)

Of (1) $\Rightarrow$ $\vec{P} = 3 \times 8.85 \times 10^{-12}\,\frac{F}{m} \times 10^{2}\,\frac{V}{m} = 26.55 \times 10^{-10}\,\frac{F \times V}{m^2}$

Polarisation vector:

$\vec{P} = N\vec{p} = N\alpha\varepsilon_0\vec{E}$ (5), where N=6.02×10^{23} mol^{-1}, ε_0=8.85×10^{-12} F/m, α is atomic polarisability, E is the magnitude of electric field

Of (5) $\Rightarrow$ $\alpha = \frac{P}{N\varepsilon_0 E}$ (6)

Of (6) $\Rightarrow$ α=0.5×10^{-23} m^3

Refractive index:

$n = \sqrt{\varepsilon_r\mu_r}$ (7), where ε_r is the relative permittivity, μ_r is the relative permeability

Of (7) $\Rightarrow$ $n = \sqrt{4 \times 0.99} = 1.99$

Answer:

polarisation vector: $26.55 \times 10^{-10}\,\frac{F \times V}{m^2}$

atomic polarisability: 0.5×10^{-23} m^3

refractive index: 1.99