DEPARTMENT OF PHYSICS AND NANOTECHNOLOGY
SRM INSTITUTE OF SCIENCE AND TECHNOLOGY

18PYB101J-Electromagnetic Theory, Quantum Mechanics, Waves and Optics

Module I Lecture-16

Solving Problems

1. Calculate the polarisability and relative permittivity in hydrogen gas with a density of 9.8×10^{26} atoms/m^3. Given the radius of the hydrogen atom to be 0.50×10^{-10} m.

Solution:

Given: $N = 9.8\times10^{26}$ atoms/m^3 $R = 0.50 \times 10^{-10}$ m ; α_e = ?; ε_r = ?

We Know

$\alpha_e = 4\pi\varepsilon_0 R^3$

$\alpha_e = 1.389\times10^{-41}$ Fm^2

To find ε_r we know that,

$\alpha_e = \varepsilon_0\times(\varepsilon_r - 1)/N$

$\{(N\,\alpha_e)/\varepsilon_0\}+1 = \varepsilon_r - 1$

$1.0015 = \varepsilon_r$

2. If a NaCl crystal is subjected to an elecrtical filed of 1000 V/m and the resulting polarization is 4.3×10^{-8} C/m^2 , calculate the relative permittivity of NaCl.

Solution:

Given: E = 1000 V/m, P = 4.3×10^{-8} C/m^2; $\varepsilon_0 = 8.854 \times 10^{-12}$ F/m

We Know that

$P = \varepsilon_0 (\varepsilon_r - 1)E$

$\varepsilon_r = 1 + (P/ \varepsilon_0 E)$

$5.86 = \varepsilon_r$

3. Calculate the electronic polarisabilty of argon atom given $\varepsilon_r = 1.0024$ at NTP and N= 2.7×10^{25} atoms/m^3

Solution:

Given: $\varepsilon_r = 1.0024$; N= 2.7×10^{25} atoms/m^3 ; $\varepsilon_0 = 8.854 \times 10^{-12}$ F/m

We Know that

$P = \varepsilon_0 (\varepsilon_r - 1)E$

Also, $P = N\alpha_e E$

$\alpha_e = \{\varepsilon_0 (\varepsilon_r - 1)\}/N$

Subtituting the given values, we have

$\alpha_e = 7.9\times10^{-40}$ Fm^2

4. The dielectric constant of He gas at NTP is 1.0000684. Calculate the electronic polarisability of He atoms if the gas contains 2.7×10^{25} atoms per m^3

Solution:

Given: $\varepsilon_r = 1.0000684$; $N = 2.7\times10^{25}$ atoms/m^3 ; $\varepsilon_0 = 8.854 \times 10^{-12}$ F/m

We Know that

$$\alpha_e = \{\varepsilon_0 (\varepsilon_r - 1)\}/N$$

Substituting the given values, we have

$$\alpha_e = 2.242\times10^{-41} Fm^2$$