Question #59737, Physics / Electromagnetism

Carbon tetrachloride at 20 degrees Celsius has relative permittivity of 2.24 and density of 1.60 g / cm^3. Its molecular weight is 156. Calculate the dipole moment of a single molecule of the substance when it is in an electric field of 10^7 V / m.

CCl_4
T=20 ^{0}C
ε=2,24
ρ=1,6 g/cm^3 = 1600 kg/m^3
M=156·10^{-3} kg / mol
E=10^7 V/m

μ- ?

Solution

The induced electric moments of liquid molecules are the same for all molecules. The induced moment proportional to the field strength acting on the molecule $\mu = \alpha E$, where α - polarizability of the molecule. In accordance with the Clausius - Mossotti for nonpolar gases and liquids, we get the formula: $\frac{(\varepsilon-1)M}{(\varepsilon+2)\rho} = \frac{4}{3}\pi N_A \alpha$, consequently the dipole moment of a single molecule of the substance $\mu = \frac{3(\varepsilon-1)M \cdot E}{4\pi(\varepsilon+2)\rho N_A}$.

$\mu = \frac{3 \cdot 1{,}24 \cdot 156 \cdot 10^{-3} kg/mol \cdot 10^7 V/m}{4 \cdot 3{,}14 \cdot 4{,}24 \cdot 1600\ kg/m^3 \cdot 6{,}022 \cdot 10^{23} mol^{-1}}$=11,3·$10^{-23}$ C/m.

Answer the questions: μ=11,3·10^{-23} C/m.