CLAUSIUS-MOSSOTTI FORMULA - EXAMPLES

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Reference: Griffiths, David J. (2007) Introduction to Electrodynamics, 3rd Edition; Prentice Hall - Problem 4.39.

The Clausius-Mossotti formula gives the atomic polarizability in terms of the dielectric constant for a linear dielectric. We can check the formula for a few gases. The formula is

$$\alpha = \frac{3\epsilon_0}{N}\frac{\epsilon_r - 1}{\epsilon_r + 2} \tag{0.1}$$

Griffiths gives the dielectric constants for some gases at a pressure of 1 atm and temperature of $20°C = 293K$. We need the other two values to plug into the formula. We have:

$$\epsilon_0 = 8.85418782 \times 10^{-12} Farads/m \tag{0.2}$$

We can use the ideal gas law $PV = nRT$ to find the number of molecules in a cubic metre. Using $R = 8.205746 \times 10^{-5} m^3 atm\ K^{-1} mol^{-1}$ and $V = 1m^3$, we get, using Avogadro's number 6.0221415×10^{23}

$$n = \frac{PV}{RT} \tag{0.3}$$

$$= \frac{1}{293 \times 8.205746 \times 10^{-5}} \tag{0.4}$$

$$= 41.592\, moles/m^3 \tag{0.5}$$

$$N = 2.505 \times 10^{25}\, molecules/m^3 \tag{0.6}$$

Using these values, we get, using numbers from Griffiths's book:

Gas	$C-M$	Measured
He	0.2065	0.205
H	0.794	0.667
Ne	0.413	0.396
Ar	1.652	1.64

(Values are for $\alpha/4\pi\epsilon_0$ in units of $10^{-30}m^3$.) The values aren't a brilliant match, but they're not bad considering it's a fairly crude calculation.