

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

$$\alpha = \frac{3\epsilon_0 \epsilon_r - 1}{N \epsilon_r + 2} \quad (1)$$

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

$$\epsilon_0 = 8.85418782 \times 10^{-12} \text{Farads/m} \quad (2)$$

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

$$n = \frac{PV}{RT} \quad (3)$$

$$= \frac{1}{293 \times 8.205746 \times 10^{-5}} \quad (4)$$

$$= 41.592 \text{ moles/m}^3 \quad (5)$$

$$N = 2.505 \times 10^{25} \text{ molecules/m}^3 \quad (6)$$

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.