Answer on Question #66115, Physics / Mechanics | Relativity

Define mean free path of a molecule in a gas. Derive the law of distribution of free paths.

Answer:

A moving molecule the average distance travels the mean free path between successive collisions, which change its direction or energy or other properties of particles.

Consider a large number of molecules at a certain time. As they travel, they will collide with each other and with other molecules. Let the number of molecules that survive a collision at a distance r of the path be r. If each molecule is allowed to move to a larger distance dx, more collisions will occur. Suppose that the number of collisions is proportional to the number of molecules N and specific dx. That is, the number of molecules removed by these collisions will be proportional to. Since their number decreases with increasing area, we can write

$dN = -P_c N dx$

where P_c is a constant of proportionality and is called the Collision probability.

One can rewrite the above equation as

$dN/N = -P_c dx$

This can be integrated to $N = N_0 e^{-Pcx}$

where N_0 is the number of molecules at $x = 0$.

From the equation we find that number of molecules surviving, a collision decreases exponentially. Further, the probability that a gas molecule will cover a distance x without making any collision is

$N/N_0 = f(x) = e^{-P_c x}$.

This is the law of distribution of free paths. $P_c = 1 / l$,

where l is mean free path.

Thus

$N/N_0 = e^{-x/l}$

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