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Maxwell Velocity Distribution Law

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In spherical polar coordinate (c, θ, ϕ) the volume element can be written as

$$dudvdw = c^2 \, dc \sin\theta \, d\theta \, d\phi .$$

substituting this value in (14) , we get the number of molecules having velocities lying between c and c + dc , $\theta + d\theta$ and $\phi + d\phi$

$$dn = na^3 e^{-bc2} c^2 \, dc \sin\theta \, d\theta \, d\phi . \qquad (15)$$

Integrating this equation over θ and ϕ with the limits $\theta = 0$ to $\theta = \pi$ and $\phi = 0$ to $\phi = 2\pi$ we get an expression for number of molecules having the velocities lying between c and c + dc . Thus

$$dn_c = na^3 e^{-bc2} c^2 dc \int_0^{\pi} sin\theta \, d\theta \int_0^{2\pi} d\emptyset$$

$$= 4 \pi a^3 e^{-bc2} c^2 dc \qquad (16)$$

This is known as Maxwell distribution law .

It gives the complete knowledge of the gas only in the statistical sense from this probability of its velocity lying between c and c+ dc is

$$f(c)\,dc = 4\pi a^3 e^{-bc2} c^2\,dc \tag{17}$$

Let $(bc^2)^{1/2} = X$ then (17) becomes

$$f(X)\,dX = 4\pi^{-1/2} e^{-X} X^2\,dX$$

Or ,

$$f(X) = 4\pi^{-1/2} e^{-X} X^2 \ . \tag{18}$$

This equation is universal . In this form , the distribution function depends neither on the kind of gas nor on the temperature .

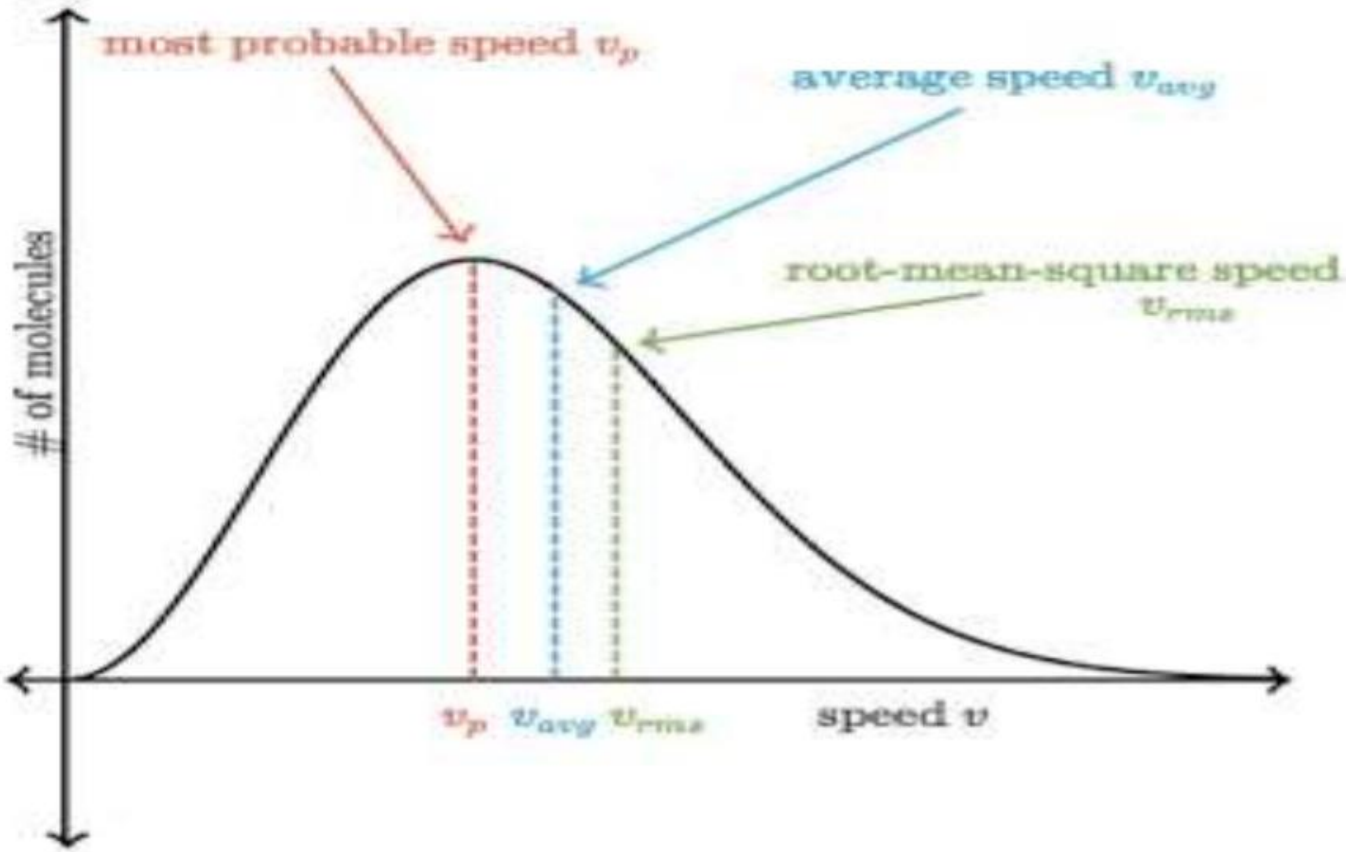

Figure 1 . The Maxwell distribution function as a function of speed .

From fig 1 , we obtain the probability when X =1 is the greatest .Thus the gas has the most probable velocity X = 1

Determination of the constants :

Since total number of molecules per unit volume having velocities 0 and $\propto$ is in n , we have

$$4 \pi n a^3 \int_0^{\propto} e^{-bc2} c^2 dc = n \qquad (19)$$

Integrating this we can determine a

Let us put

$bc^2 \quad = X$

$dc = ½\ b^{-1/2}\, X^{-1/2}\, dX$,

Eq(19) becomes

$$2\pi n a^3\ ½\ b^{-1/2} \int_0^{\propto} e^{X}\ X^{1/2}\, dX \qquad = n$$

Or ,

$$a = (\ b/\pi\ )^{1/2} \qquad (20)$$