Thermal Physics
(Maxwell Distribution Law)
Lecture - 6

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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

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

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

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

Or ,

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

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

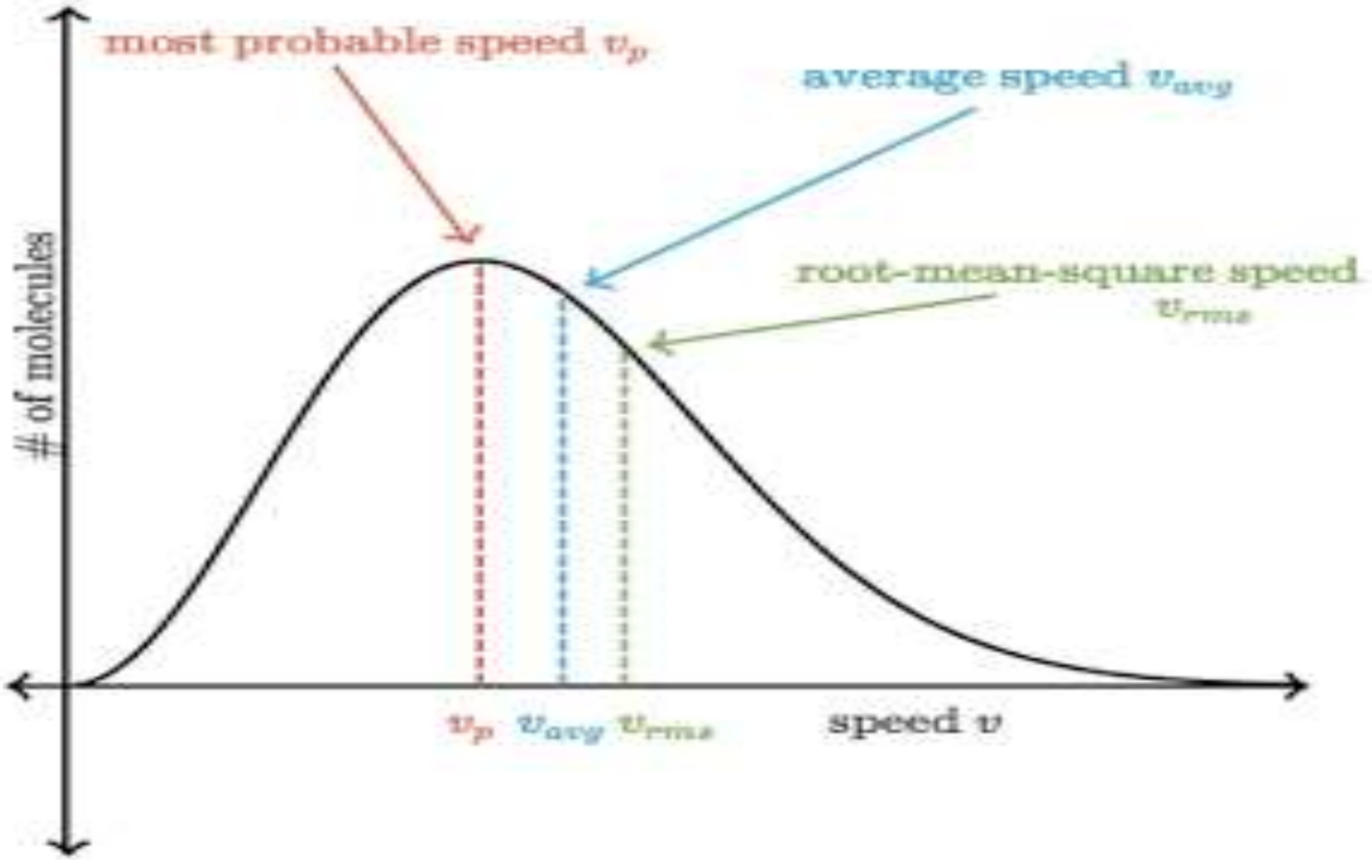

Figure 1 . The Maxwell distribution function as a function of speed .

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

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

Integrating this we can determine a

Let us put

$bc^2 = X$

$dc = \frac{1}{2} b^{-1/2} X^{-1/2} dX$,

Eq(19) becomes

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

Or ,

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