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* Maxwell distribution of molecular kinetic Energy :-

From Maxwell distribution of molecular velocity -

$$\frac{dN_c}{N} = 4\pi\left(\frac{M}{2\pi RT}\right)^{3/2} c^2 \exp\left(-\frac{Mc^2}{2RT}\right) dc \quad \text{—— (1)}$$

With the help of this eqn – (1) it is possible to know how the kinetic energies of translation of molecules are distributed amongst the various molecules. The fraction of molecules having kinetic energies in the range of ε & $\varepsilon + d\varepsilon$. viz.

$\frac{dN_c}{N}$, can be determined as follows :

$$\varepsilon = \frac{1}{2}mc^2$$

$$\text{or} \quad c^2 = 2\varepsilon/m$$

$$2c\,dc = (2/m)(d\varepsilon)$$

$$\text{or} \quad c\,dc = \frac{d\varepsilon}{m} \quad \text{—— (2)}$$

$$\text{Thus,} \quad c^2 dc = c\frac{d\varepsilon}{m} = \left(\frac{2\varepsilon}{m}\right)^{1/2}\left(\frac{d\varepsilon}{m}\right) = \frac{\sqrt{2\varepsilon}}{(m)^{3/2}} d\varepsilon \quad \text{—— (3)}$$

Substituting the above value of c^2dc in eqn – (1) we have,

$$P(c)dc = \frac{dN_c}{N} = 4\pi\left(\frac{m}{2\pi KT}\right)^{3/2}\left(\frac{\sqrt{2\varepsilon}}{(m)^{3/2}}\right) d\varepsilon \exp\left(-\frac{\varepsilon}{KT}\right) \quad \text{—— (4)}$$

$$= \frac{2\sqrt{\varepsilon}}{\sqrt{\pi}(KT)^{3/2}} \exp\left(-\frac{\varepsilon}{KT}\right) d\varepsilon \quad \text{—— (5)}$$

This eqn – (5) is the expression of Maxwell distribution of molecular kinetic energies.

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Molecular Velocities

The three different types of velocities which are used to study of gases are :-

1). Most Probable velocity :-

It is defined as the velocity of gas possessed by maximum no. of molecules at a given temperature.
The equation for Maxwell distribution of velocities may be written as —

$$\frac{N}{dU_x} = 4\pi \left(\frac{M}{2\pi RT}\right)^{3/2} \exp\left(-\frac{MU_x^2}{2RT}\right) U_x^2 \quad \text{—(1)}$$

for maxima & minima Conditions, this equation is differentiated w.r.t U_x and equated to zero. Then we get —

$$\left(1 - \frac{MU_x^2}{2RT}\right) U_x \exp\left(-\frac{MU_x^2}{2RT}\right) = 0.$$

Since,

$$U_x \exp\frac{-MU_x^2}{2RT} \neq 0.$$

Then,

$$1 - \frac{MU_x^2}{2RT} = 0.$$

or

$$\frac{MU_x^2}{2RT} = 1$$

$$MU_x^2 = 2RT$$

$$\boxed{U_x = \sqrt{\frac{2RT}{M}}}$$

where, 'U_x' is the most Probable velocity. M = Mol. mass of the gas

Problems

(1) Calculate the most probable velocity of H_2 gas.

Given, molar mass of H_2 = 2.016 g mol^{-1}
= 2.016×10^{-3} kg mol^{-1}

(Ans 1.50×10^{3} m sec^{-1})

(2) The most probable speed (velocity) at T K of CO_2 gas is 9×10^{4} cm sec^{-1}. Calculate the temperature.

(Hints $1J = 10^{7}$ erg
$R = 8.314$ J K^{-1} mol^{-1})

(Ans → 2143 K)

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