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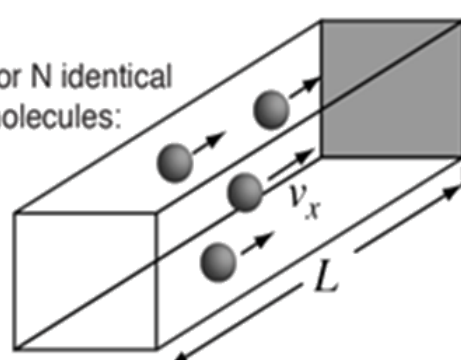
Average Kinetic Energy of a Gas Molecule, Significance of the Kinetic Theory of Gases (For CBSE, ICSE, IAS, NET, NRA 2022)

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**Average Kinetic Energy of a Gas Molecule**

The Equation of Force and Pressure

For N identical molecules:



For N molecules

$$\bar{F} = \frac{m[v_{1x}^2 + v_{2x}^2 + v_{3x}^2 + \dots + v_{Nx}^2]}{L}$$

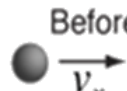
but this can be related to the average:

$$\bar{v}_x^2 = \frac{[v_{1x}^2 + v_{2x}^2 + v_{3x}^2 + \dots + v_{Nx}^2]}{N}$$

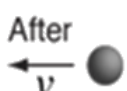
Force of molecular collision with wall

$$\bar{F} \Delta t = \Delta p = 2mv_x$$

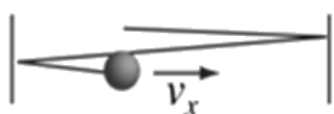
Before



After



Perfectly elastic collision with wall



The time for a "round trip" is  $\Delta t = \frac{2L}{v_x}$

so the average force is  $\bar{F} = \frac{2mv_x}{\frac{2L}{v_x}} = \frac{mv_x^2}{L}$

and for N molecules:  $\bar{F} = \frac{mN\bar{v}_x^2}{L}$

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We know that  $PV = nRT$

So, from figure

$$nRT = \frac{1}{3}mv^2 N$$

Multiplying and Dividing by 2 we get-

$$nRT = \frac{2}{3} \left( \frac{mv^2}{2} \right) N$$

Rearranging equation we get-

$$\frac{mv^2}{2} = \frac{3}{2} \frac{nRT}{N} = \frac{3}{2} \frac{RT}{\frac{N}{n}}$$

- Here, N is the total number of gas molecules in a given region of space
- n is the number of moles of gas present in a given region of space.
- $\frac{N}{n} = N_A$  Avogadro's number
- Avagadro's number in this context is the number of molecules present in the one mole of gas.  $N_A = 6.022140857 \times 10^{23}$ .
- Substituting  $N_A$  in equation, Average Kinetic Energy of a gas molecule is given by-

$$K.E = \frac{3}{2}k$$

### Significance of the Kinetic Theory of Gases

- As we know the Temperature, we can directly figure out the average Kinetic energy of a gas molecule. No matter what gas are you considering, except it is an ideal gas.
- one can accurately calculate the microscopic parameters like Momentum, Velocity, Internal energy, Kinetic energy, Thermal energy etc. and Visa-Versa. , As we Know the macroscopic parameters of gases like Pressure, Volume, Temperature etc. ,

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