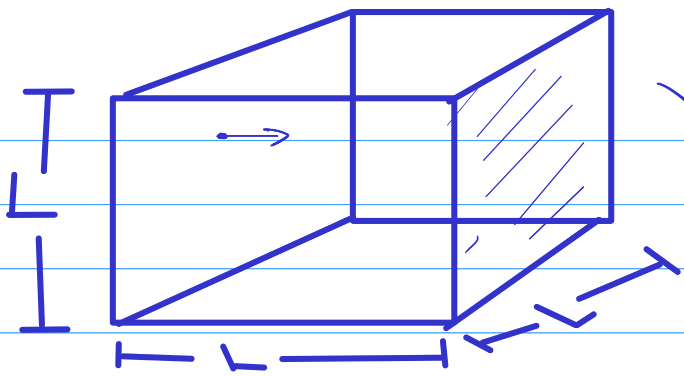
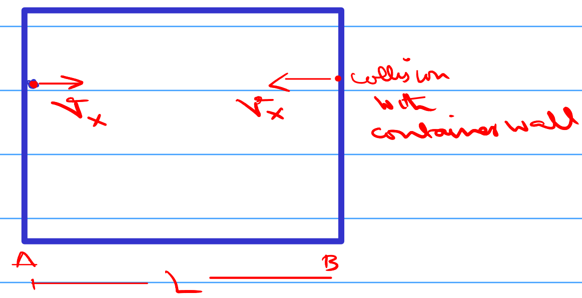


Vol = LLL
= L^3

∴ molecule exerts a force on the wall of container



$$\text{Force} = \frac{d\vec{P}}{dt}$$

let us solve the above for x direction

KTG suggests that collision is elastic (Kinetic energy is conserved)

Change in momentum $= mv_x - (m(-v_x)) = 2mv_x$

time taken in one collision = time from A to B + time from B to A

$$= \frac{L}{v_x} + \frac{L}{v_x} = \frac{2L}{v_x}$$

∴ force on wall of container due to one molecule $= \dfrac{2mv_x}{2L/v_x}$

$$= \frac{2mv_x^2}{2L} = \frac{mv_x^2}{L}$$

∴ force due to N molecules $= \dfrac{Nmv_x^2}{L}$

$$\text{Pressure} = \frac{F}{\text{Area}} = \frac{F \cdot L}{\text{Area} \cdot L} = \frac{F \cdot L}{\text{Vol.}} = \frac{Nmv_x^2}{\cancel{L}}\left(\frac{\cancel{L}}{V}\right)$$

$$P = \frac{Nmv_x^2}{V} \Rightarrow \boxed{PV = Nmv_x^2}$$

Since there is no prefferable direction for velocity

$$\therefore v_{net}^2 = v_x^2 + v_y^2 + v_z^2$$

$v_x^2 = v_y^2 = v_z^2$ (all direction are equally prefferable)

$$\therefore v_{net}^2 = v_x^2 + v_x^2 + v_x^2 \Rightarrow v_x^2 = \frac{v_{net}^2}{3}$$

$$\therefore \boxed{PV = \frac{N m v_{net}^2}{3}}$$

$P \rightarrow$ pressure exerted by N molecules on container wall.
$m \rightarrow$ mass of one molecule
$v_{net} \rightarrow$ net velocity of one molecule.
$N \rightarrow$ no of molecules
$V \rightarrow$ Volume of container

mole $\rightarrow$ represents a number $= 6.023 \times 10^{23}$

like 1 dozen $\rightarrow$ 12 in number
represents
a number $= 12$

$$\boxed{PV = \frac{N m v_{net}^2}{3}}$$

Kinetic energy of one molecule $= \frac{1}{2} m v^2$

Total energy = Kinetic energy + $\underline{\text{potential energy}}$
$= 0$ in KTG

$E = KE + PE$

$\therefore E = K.E$ [(total energy = KE (in KTG)]

$\therefore$ energy of one molecule $= \frac{1}{2} m v^2$

$$E = \frac{1}{2} \cancel{m} \left(\frac{3PV}{N \cancel{m}} \right)$$

$$E = \frac{3}{2} \frac{PV}{N}$$ [energy of one molecule]

$\therefore$ energy of N molecules $= NE = \frac{3}{2} PV$

now 1 mole of molecules $= \underline{6.023 \times 10^{23}}$ molecules
Avagadro's no. represented by N_{AV}

$\therefore$

$\therefore$ 1 molecule $= \frac{1 \text{ mole}}{N_{AV}}$

$\therefore$ N molecules $= \frac{N}{N_{AV}}$ moles

Since

$E = \frac{3}{2} \frac{PV}{N}$ is energy of one molecules

What will be energy of one mole.

Since 1 molecules $= \frac{1 \text{ mole}}{N_{AV}}$

$\therefore$ energy of one mole $= \frac{3}{2} \frac{PV}{(N/N_{AV})} = \frac{3}{2} \frac{PV}{N} (N_{AV})$

If we have n moles.

then energy $= n \left[\frac{3}{2} \frac{PV}{N} (N_{av}) \right]$

Three gas Laws

① Boyle's Law $P \propto \frac{1}{V}$ [If no of moles & Temp is constant]

② Charle's Law $V \propto T$ [If Pressure and no of molecules]

③ Avagadro's Law $V \propto n$ [If Pressure & Temp are constant]

combine

$$\boxed{PV = nRT}$$

$R = 8.31$ universal gas constant

If n & T are constant

$PV = \text{const}$

$\therefore P \propto \frac{1}{V}$ Boyle's Law

If P & n are constant

$V \propto T$ Charle's Law

If P & T are const

$V \propto n$ Avagadro's Law

$$\boxed{PV = nRT}$$ gas Law [for n moles]

No of molecules = no of moles $\times$ Avagadro no.

$N = n N_{AV}$

$$\boxed{PV = \frac{N}{N_{AV}} RT}$$ gas Law for N molecules

we define a new constant $K_B = \frac{R}{N_{AV}}$ called Boltzman constant

$$\boxed{PV = N K_B T}$$

we also know that $PV = \frac{N m \overline{v^2}}{3}$

$$\therefore \quad \cancel{N} K_B T = \frac{\cancel{N} m v^2}{3}$$

$$m v^2 = 3 K_B T$$

xlply both side by $\frac{1}{2}$

$$\underbrace{\frac{1}{2} m v^2} = \frac{3}{2} K_B T$$

$$\boxed{\text{energy of one molecule} = \frac{3}{2} K_B T}$$

$\underline{\underline{3}}$ came from $\underline{x, y, z}$ distribution of velocity

3 is in general replaced by degree of freedom f

$\therefore$ more general formulla

$$\boxed{\text{Energy of one molecule} = \frac{f}{2} K_B T}$$

Energy of one mole = Energy of 6.023×10^{23} molecules

or

Energy of one mole = Energy of avagadro no of molecules

$$\text{Energy of Avagadro no of molecules} = N_{AV} \frac{f}{2} K_B T$$

$$= \cancel{N_A} \frac{f}{2} \frac{R}{\cancel{N_A}} T$$

$$\text{Energy of one mole} = \frac{f}{2} R T$$

$$\boxed{\text{energy of } n \text{ moles} = n \frac{f}{2} R T}$$