Formulas

1) $PV = nRT$

2) $PV = \frac{1}{3} \underbrace{N}_{\text{Number of molecules}} m\langle C^2\rangle$

3) $\langle E_K\rangle = \frac{3}{2} NKT$

Root mean square velocity

4) $\frac{C_{rms\_1}}{\sqrt{T_1}} = \frac{C_{rms\_2}}{\sqrt{T_2}}$

5) $[PV = NKT] \xrightarrow{\text{Derivation}}$ $PV = nRT$

and $n = \frac{N}{N_a}$

$\therefore PV = \frac{N}{N_a} Rt$

and $\frac{R}{N_a} = K$

$\therefore PV = NKT$

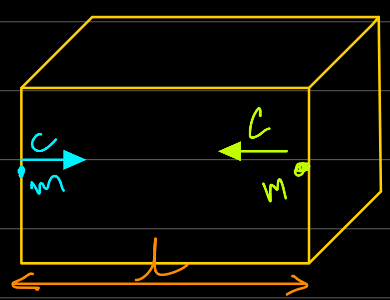
Assumtions made for idealgas:

Relationship between molecule speed and pressure exerted

To show the relationship between the speed of the molecules in a gas and the pressure it exerts, the following assumptions are made:

- The forces between molecules are negligible (except during collisions).
- The volume of the molecules is negligible compared with the total volume occupied by the gas.
- All collisions between the molecules and between the molecules and the container walls are perfectly elastic.
- The time spent in colliding is negligible compared with the time between collisions.
- There are many identical molecules that move at random.

Ideal gas



- There is pressure because molecules hit the walls of container, thus there is a change in momentum, which means there is force, and force over an area is pressure momentum

- $\Delta p = mc - (-mc)$

  $= 2mc$

- Time $= \frac{2l}{c}$

  time it takes for the travelling the distance 2L, because that's the distance moved while Δ momentum

- F = rate of change of momentum $= \frac{\Delta m}{\Delta t}$

$$= \frac{2mc}{\frac{2l}{c}} = \frac{mc^2}{l}$$

- Pressure $= \frac{\text{Force}}{\text{Area}} = \frac{\frac{mc^2}{l}}{l^2}$

$$= \frac{mc^2}{l^3}$$

l^3 is basically volume of container

$$= \frac{mc^2}{V}$$

- However c is velocity of just one gas molecule, but there are molecules moving in all 3 axis, ie c_x, c_y, c_z

$\therefore$ we take RMS value

and $\langle c_x^2 \rangle = \langle c_y^2 \rangle = \langle c_z^2 \rangle$

$$\langle c^2 \rangle = \langle c_x^2 \rangle \times 3$$

$$\langle c_x^2 \rangle = \frac{\langle c^2 \rangle}{3}$$

sub this back into eqn on previous page

$$\therefore \text{pressure} = \frac{m\left(\frac{\langle c^2 \rangle}{3}\right)}{V}$$

$$= \quad PV = \frac{1}{3} m \langle c^2 \rangle$$

this is for 1 molecule that could be moving in x, y or z, but there are N number of molecules so we multiply by N

$$\therefore \quad \boxed{PV = \frac{1}{3} N m \langle c^2 \rangle}$$

Avg K.E of molecules

equate $PV = nRT$ and $PV = \frac{1}{3} N m \langle c^2 \rangle$

number of molecules

6.03 × 10^{23}

$$nRT = \frac{1}{3} N m \langle c^2 \rangle \qquad N = n \times N_a$$

No. of moles

Boltzman constant

$$\frac{3NRT}{N_a} = Nm\langle c^2 \rangle \qquad \therefore n = \frac{N}{N_a}$$

$$k = \frac{R}{N_a} \qquad \frac{3\cancel{N}kT}{\cancel{N}} = m\langle c^2 \rangle$$

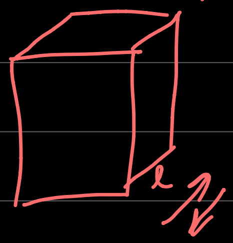
multiply by $\frac{1}{2}$ to turn it in K.E, i.e. $\frac{1}{2} m v^2 = \frac{1}{2} m \langle c^2 \rangle$

$$\therefore \frac{3}{2} kT = \frac{1}{2} m \langle c^2 \rangle$$

$$\therefore \boxed{\langle K.e \rangle = \frac{3}{2} kT}$$

and for N molecules

$$\boxed{\langle K.E \rangle = \frac{3}{2} NkT}$$



$PV = \frac{1}{3} Nm \langle c^2 \rangle$

$S = \frac{d}{t}$

$t = \frac{2l}{c}$

$mc - (-mc)$
$2mc$

$$P = \frac{F}{A} = \frac{\frac{\Delta mc}{t}}{l^2} = \frac{\frac{\cancel{2}mc}{\frac{\cancel{2}l}{c}}}{l^2} = \frac{\frac{mc}{l}}{l^2}$$

$$P = \frac{mc}{l^3} = \frac{mc}{V}$$

$c_x = c_y = c_z$

$\therefore \langle c^2 \rangle = \frac{1}{3} \langle c^2 \rangle$

$$P = \frac{m\left(\frac{1}{3}c^2\right)}{V}$$

$$PV = \frac{1}{3} mc^2$$

$$= \frac{1}{3} Nmc^2$$

$PV = nRT = \frac{1}{3} Nm \langle c^2 \rangle$

$N = n \times N_a$

$n = \frac{N}{N_a}$

$$\frac{\cancel{N}}{N_a} RT = \frac{1}{3} \cancel{N} m \langle c^2 \rangle$$

$$\frac{R}{N_a} = k$$

$$3KT = m \langle c^2 \rangle$$

$\times \frac{1}{2}$

$$\frac{3}{2} KT = \frac{1}{2} m \langle c^2 \rangle$$