Vander Waal's Equation

Course on States of Matter for Class XI

akhilesh • Lesson 16 • Aug 6, 2021

24) $P_1V_1 + P_2V_2 = P \times 1000$

27 $P = \frac{nR}{V}T$

$=$

$2A \longrightarrow 3B + 2C$

$1-x \qquad \frac{3}{2}x \qquad x$

Total moles $= 1 + \frac{3}{2}x = 1.6$

31	X	Y
	4T	T

$$\frac{3}{2} RT$$

$$= \frac{3}{2} \times 2 \times 300 = \underline{900 \text{ cal}}$$

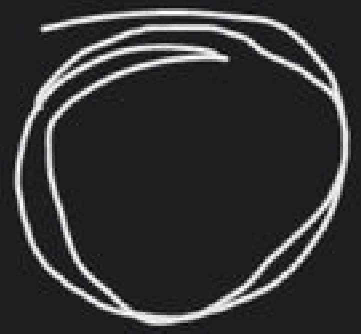
$$\frac{\frac{3}{2} RT}{N_A}$$

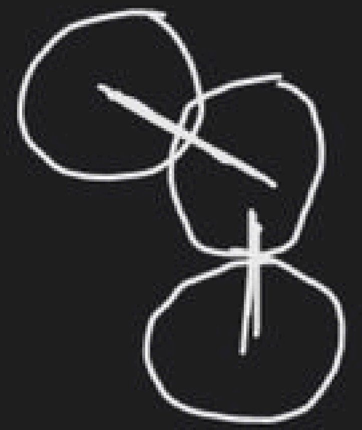
U_{mps}

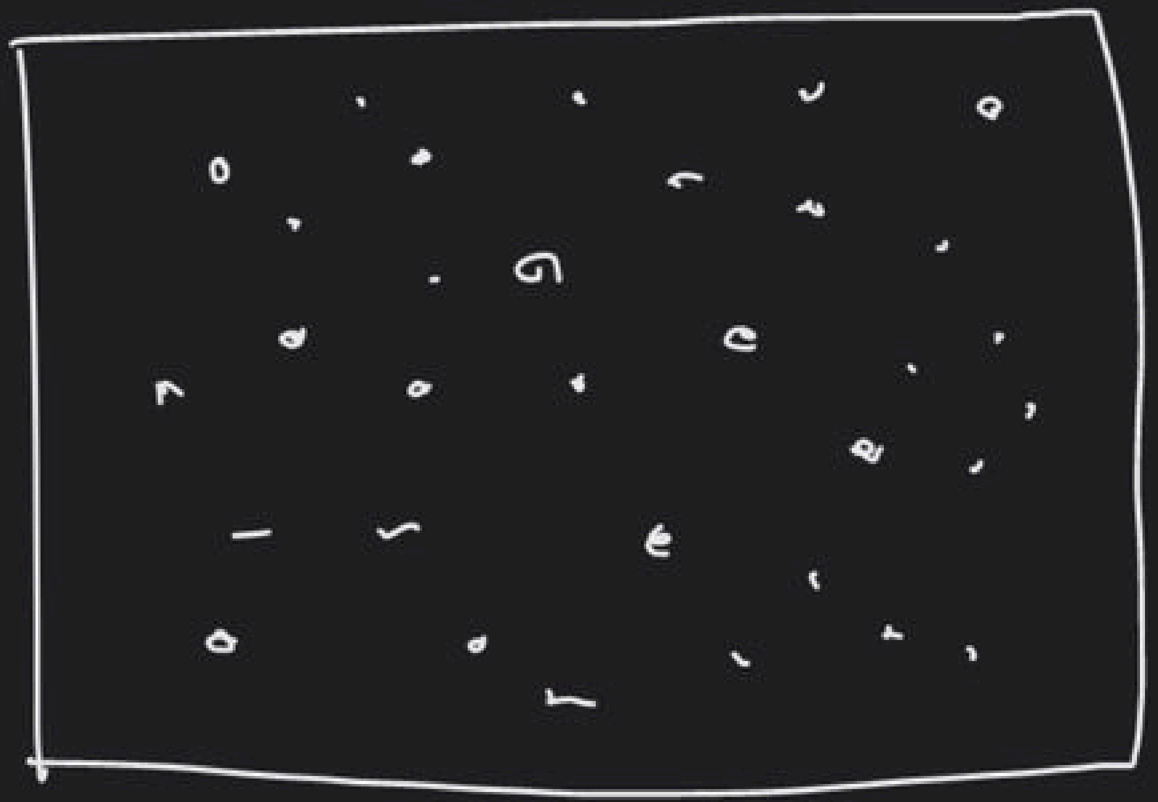
U_{rms} to $\underline{U_{rms}} + f\,U_{rms}$

$\sqrt{\frac{2RT}{M}}$ $\sqrt{\frac{3RT}{M}}$

No. of Bimolecular collisions : →

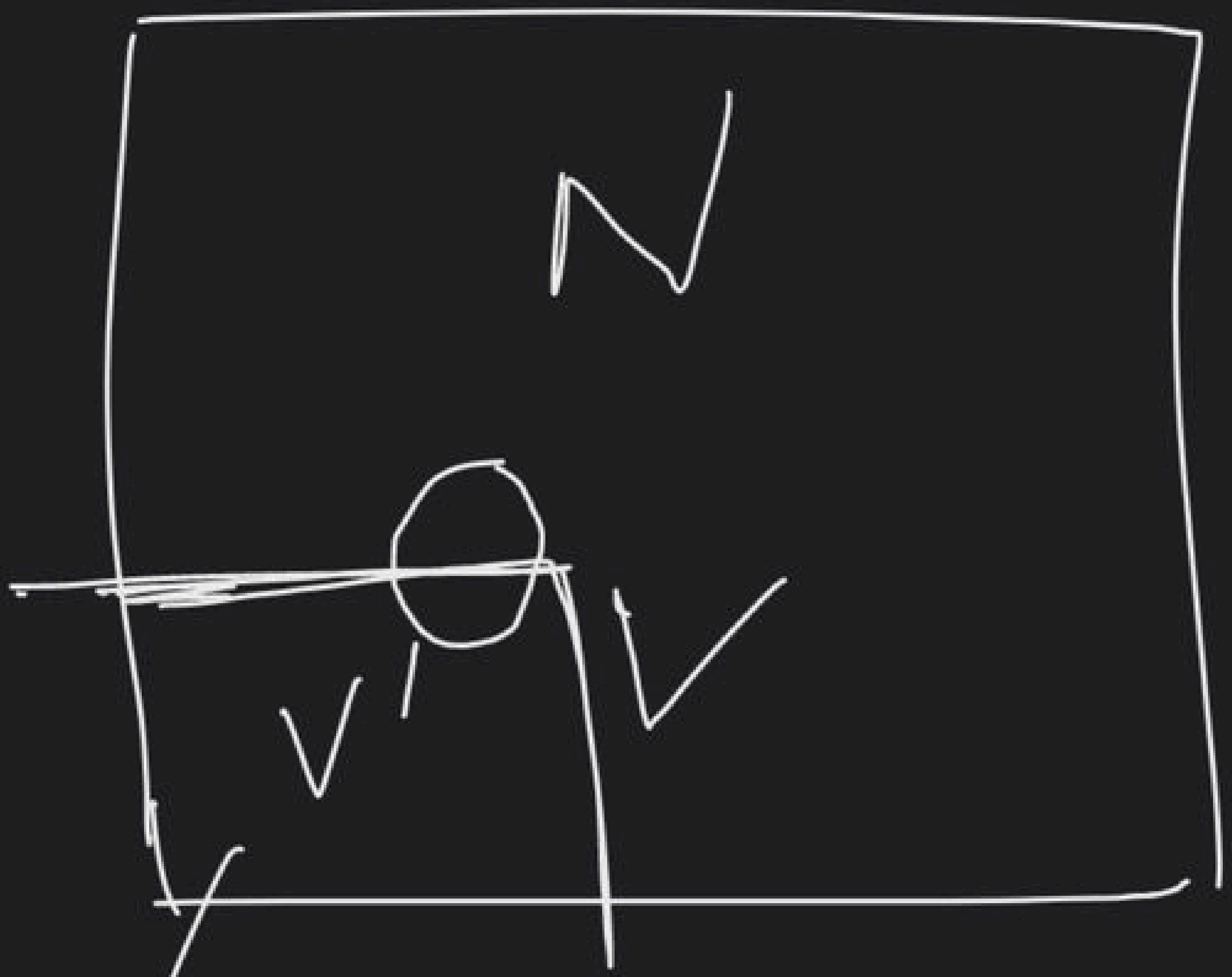






atom/Molecules are considered to be rigid & spherical in shape.

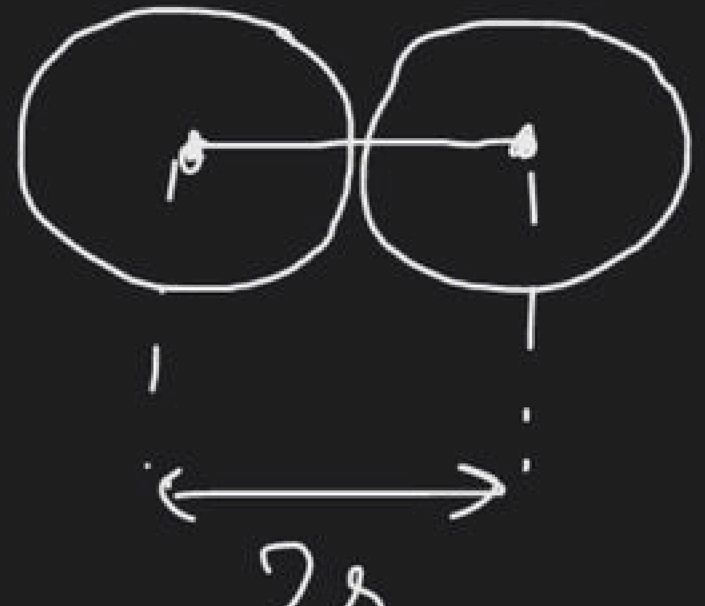
no. of molecules per unit volume $= \dfrac{N}{V} = N^*$



$=$ number density

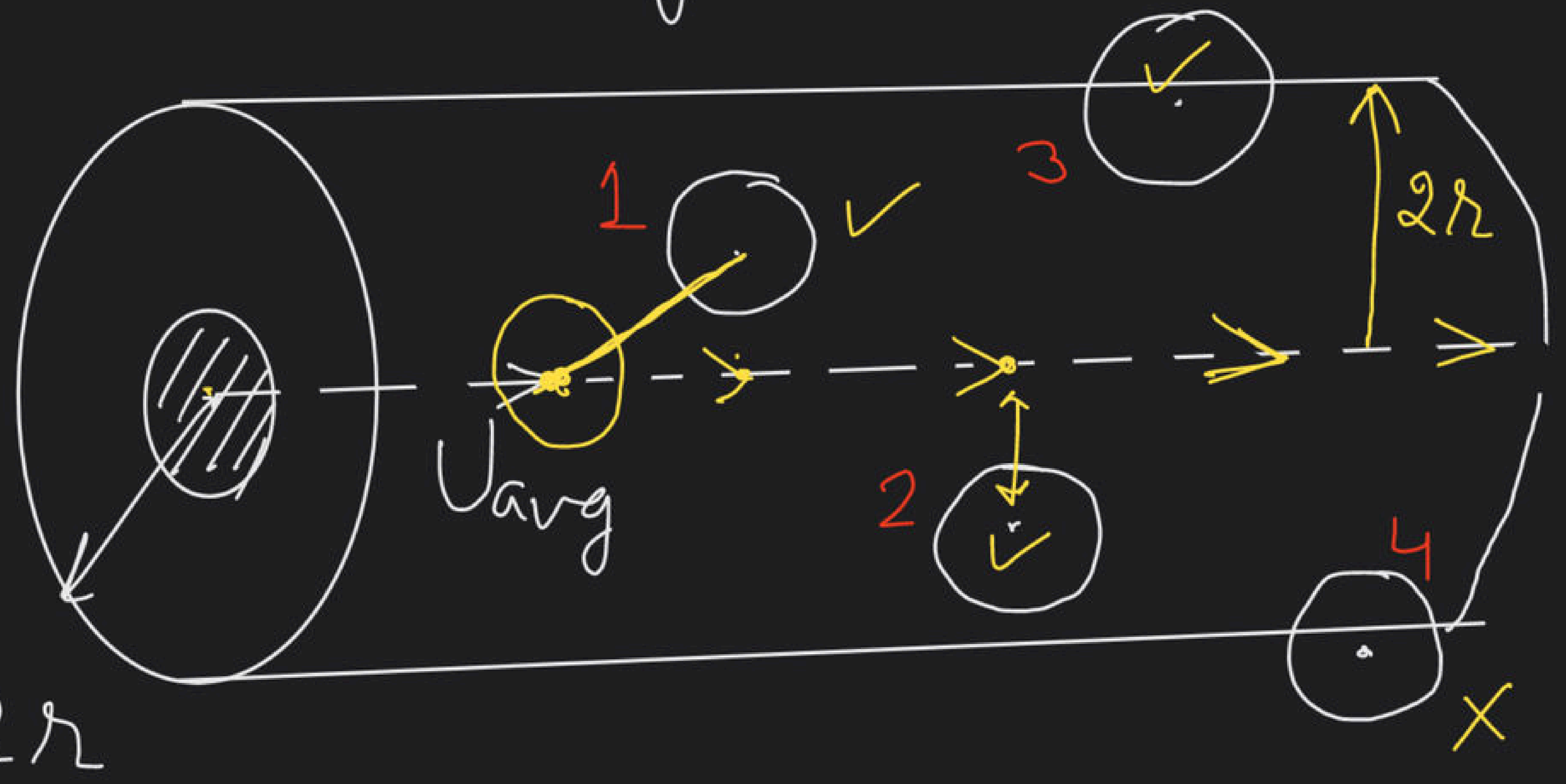
N^*V'

__collision__ __diameter__ (σ)



$2r = \sigma$

Assumption : only one molecule is moving



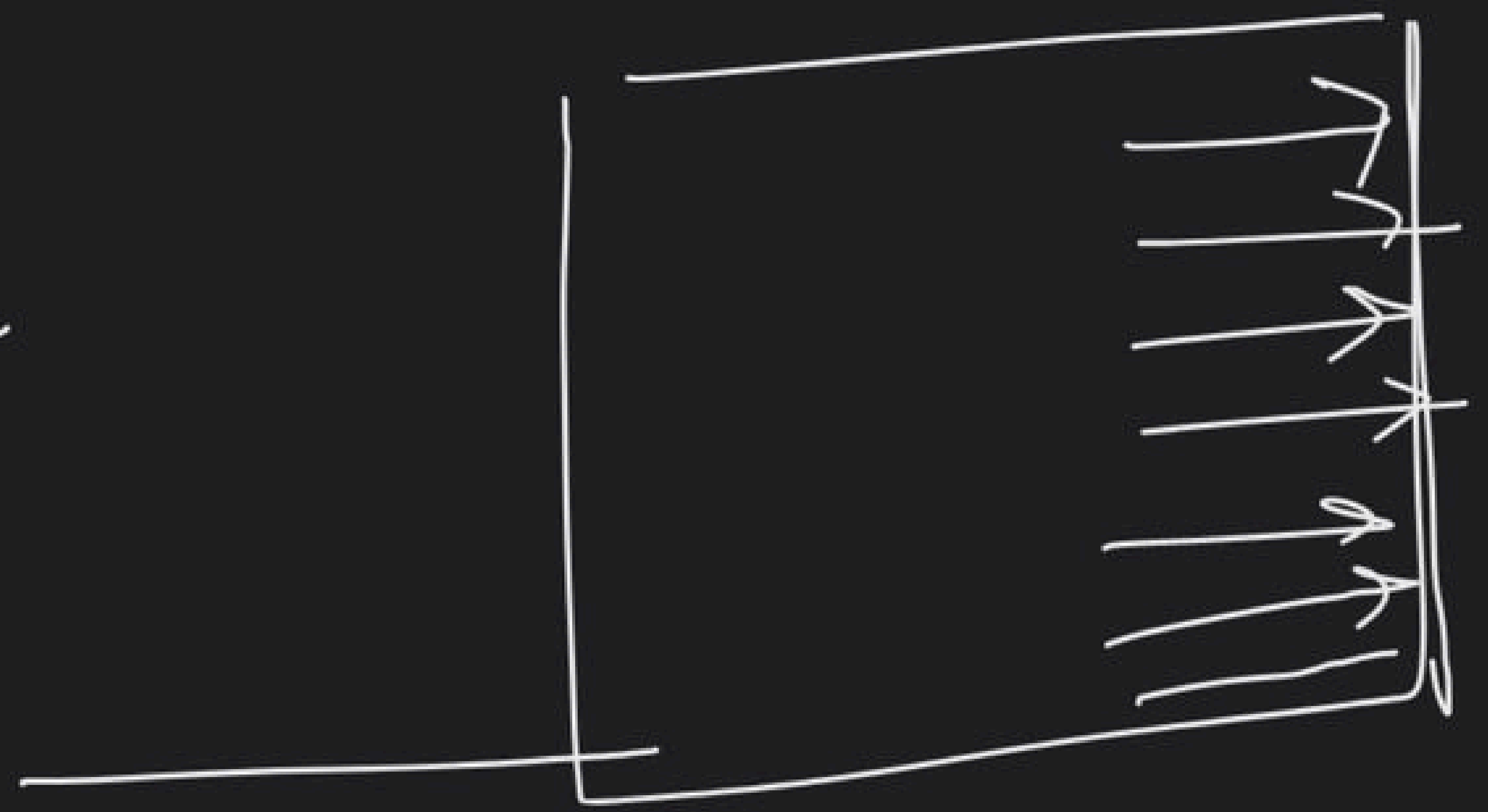
distance travelled by a molecule in one second = U_{avg}

Volume of cylinder = $\pi \sigma^2 v_{avg}$

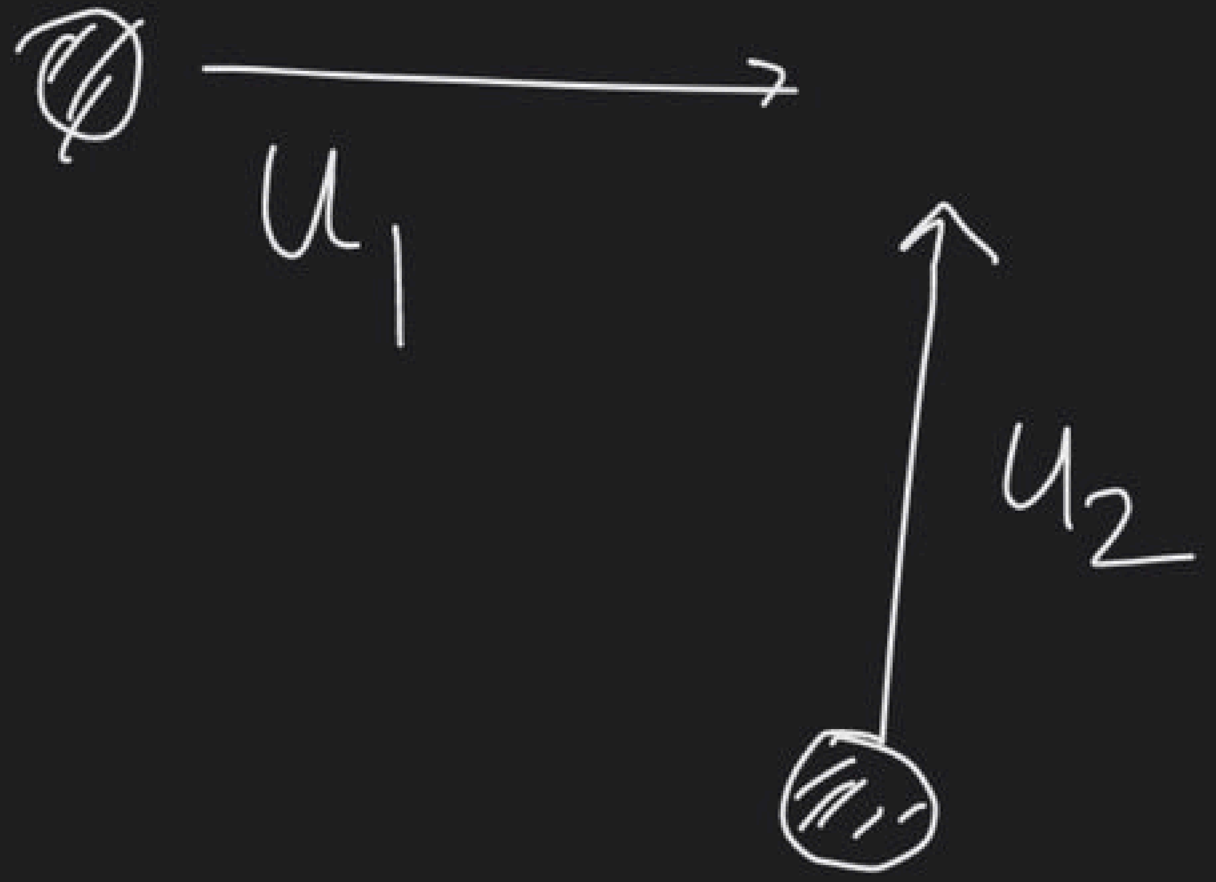
No. of Molecules in cylinder = $(\pi \sigma^2 v_{avg}) N^*$

= No of collision per second by single molecule

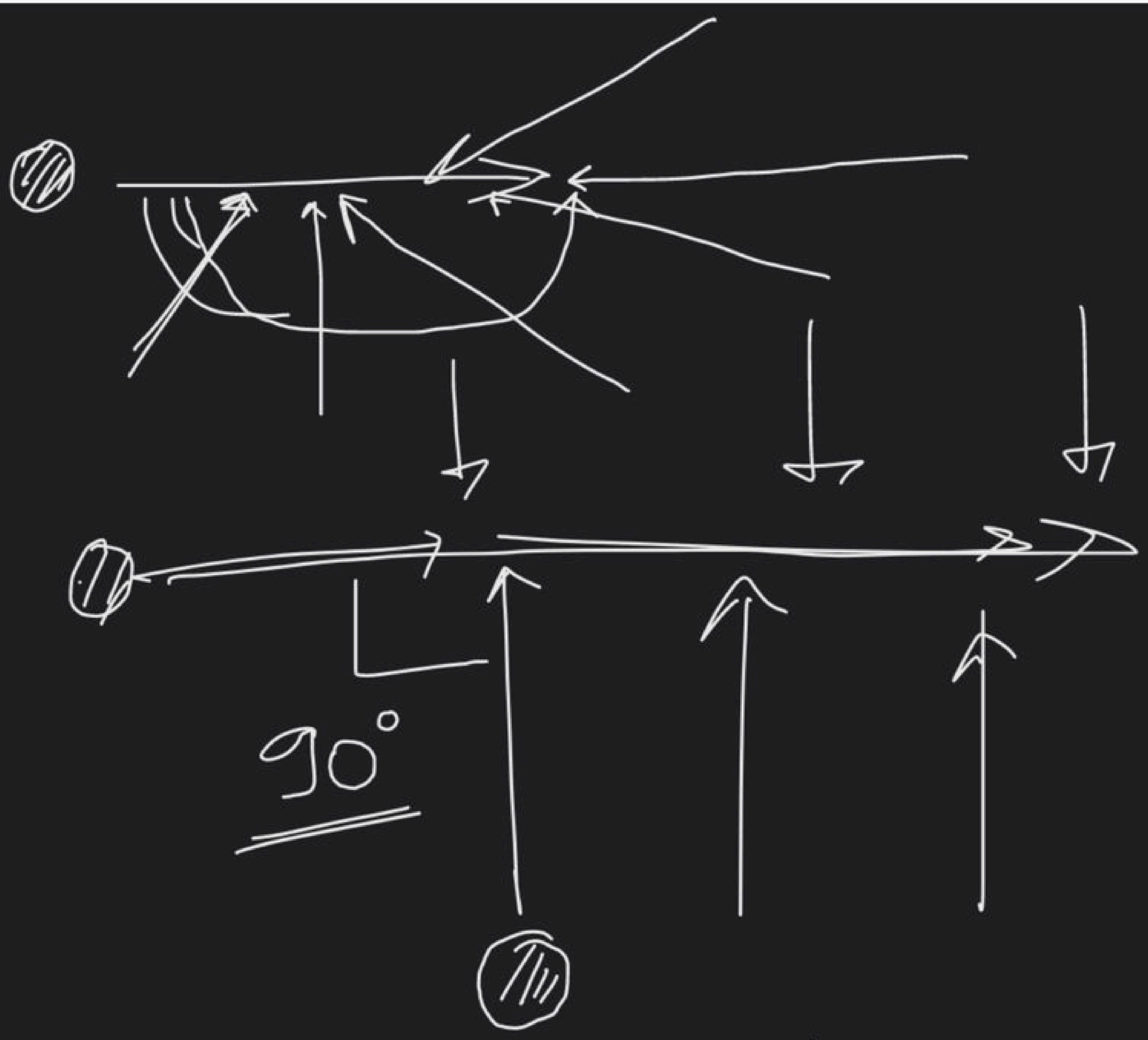
Now all the molecules are moving



$$V_{rel} = 8$$



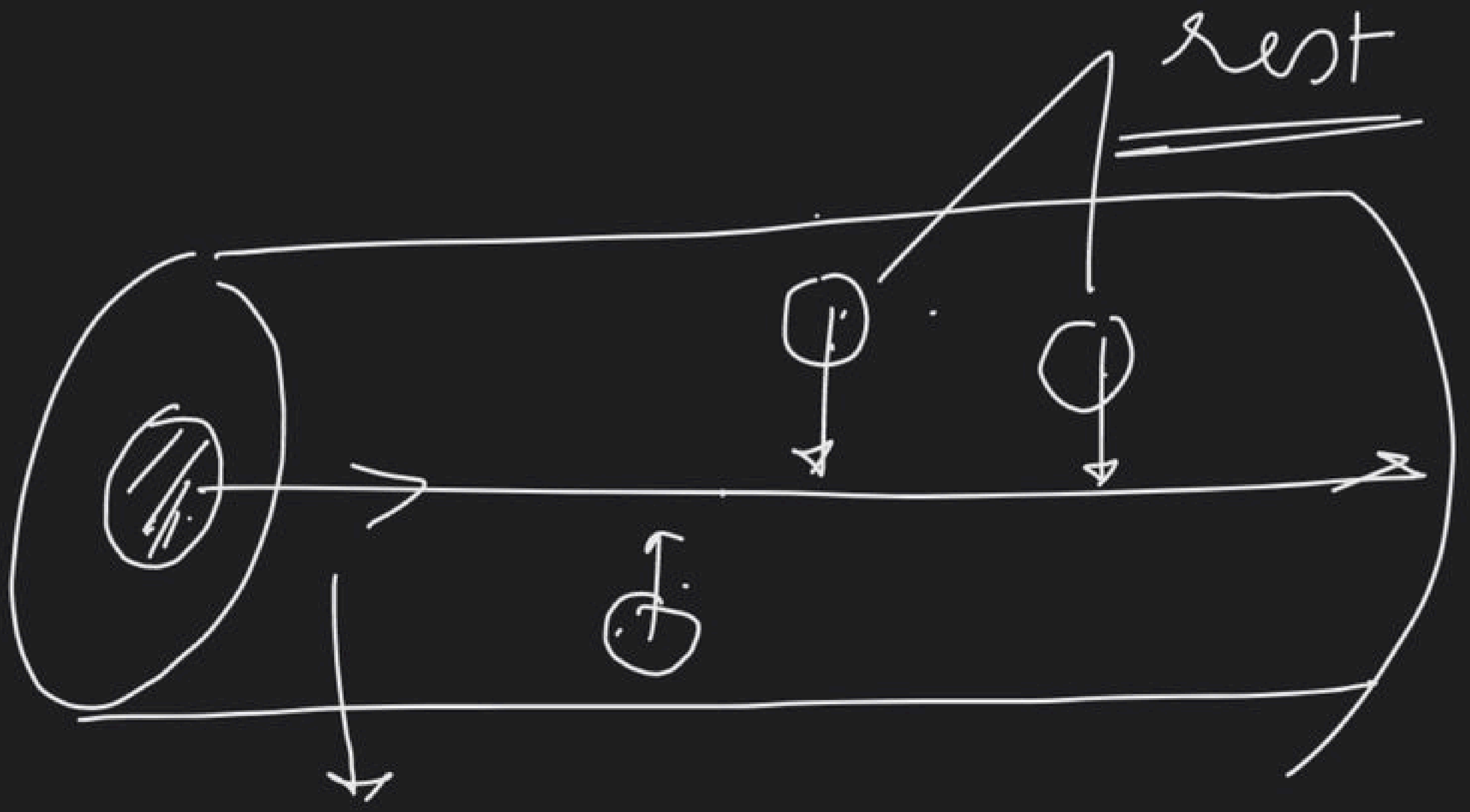
$$V_{rel} = \sqrt{u_1^2 + u_2^2}$$

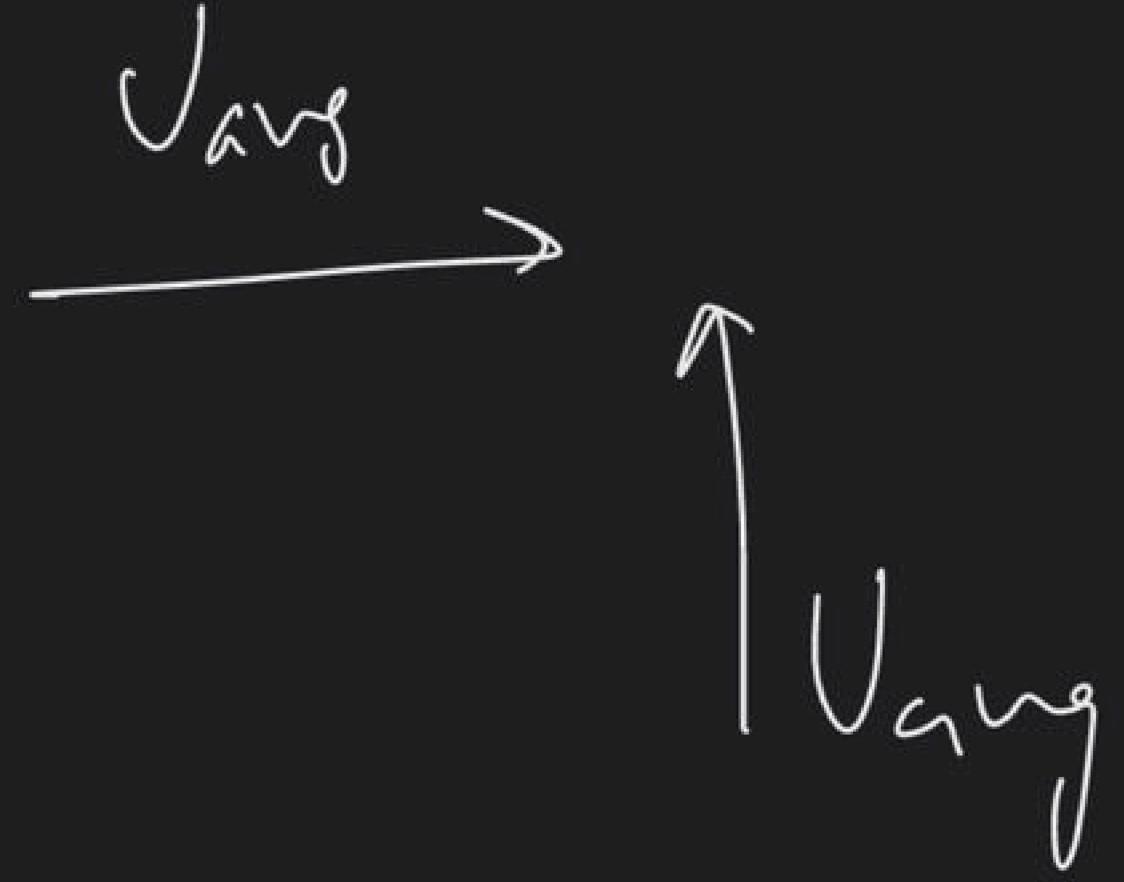


0 — 180°

molecules can collide at any angle from 0 to 180° with equal probability.

Therefore avg angle of collision can be taken 90°





$$U_{rel} = \sqrt{2}\, U_{avg}$$

no. of molecules in cylinder $= \sqrt{2}\, \pi \sigma^2 U_{avg} N^*$

no. of collision made by a single molecule in one second $= Z_1$

Total no. of collision per sec $= \dfrac{N \times Z_1}{2}$

Total no. of collision per sec per unit volume $= \dfrac{1}{2}\left(\dfrac{N}{V}\right) Z_1$

collision frequency $= Z_{11} = \dfrac{1}{\sqrt{2}} \pi \sigma^2 V_{avg} (N^*)^2$

Mean free path (λ)

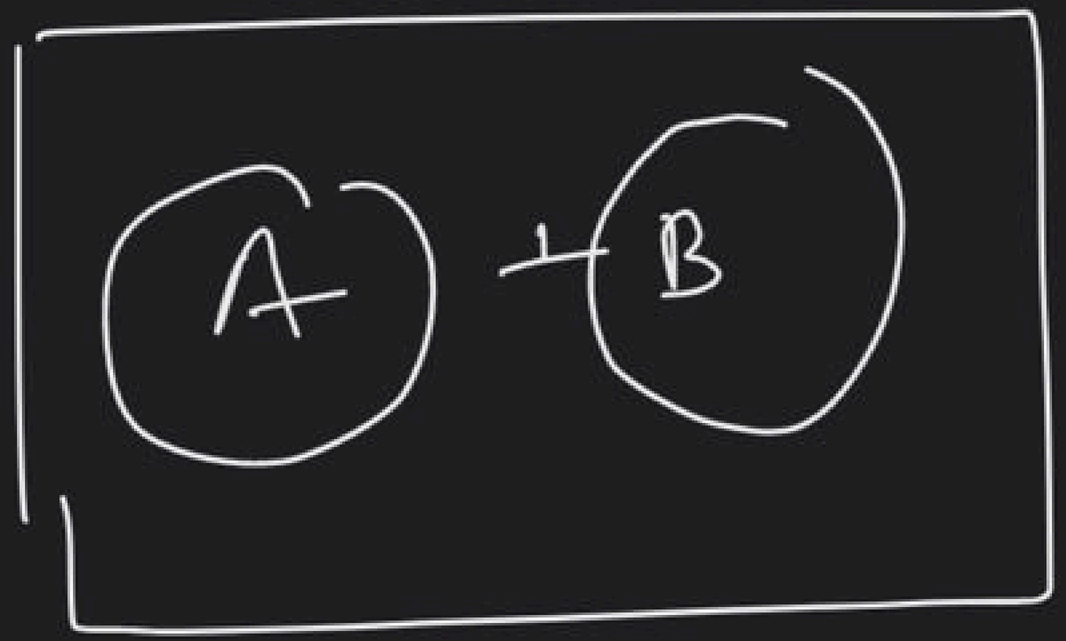
Avg distance travelled between two successive collisions.

$$\boxed{\lambda = \frac{U_{avg}}{Z_1}}$$

4

5 times Railway

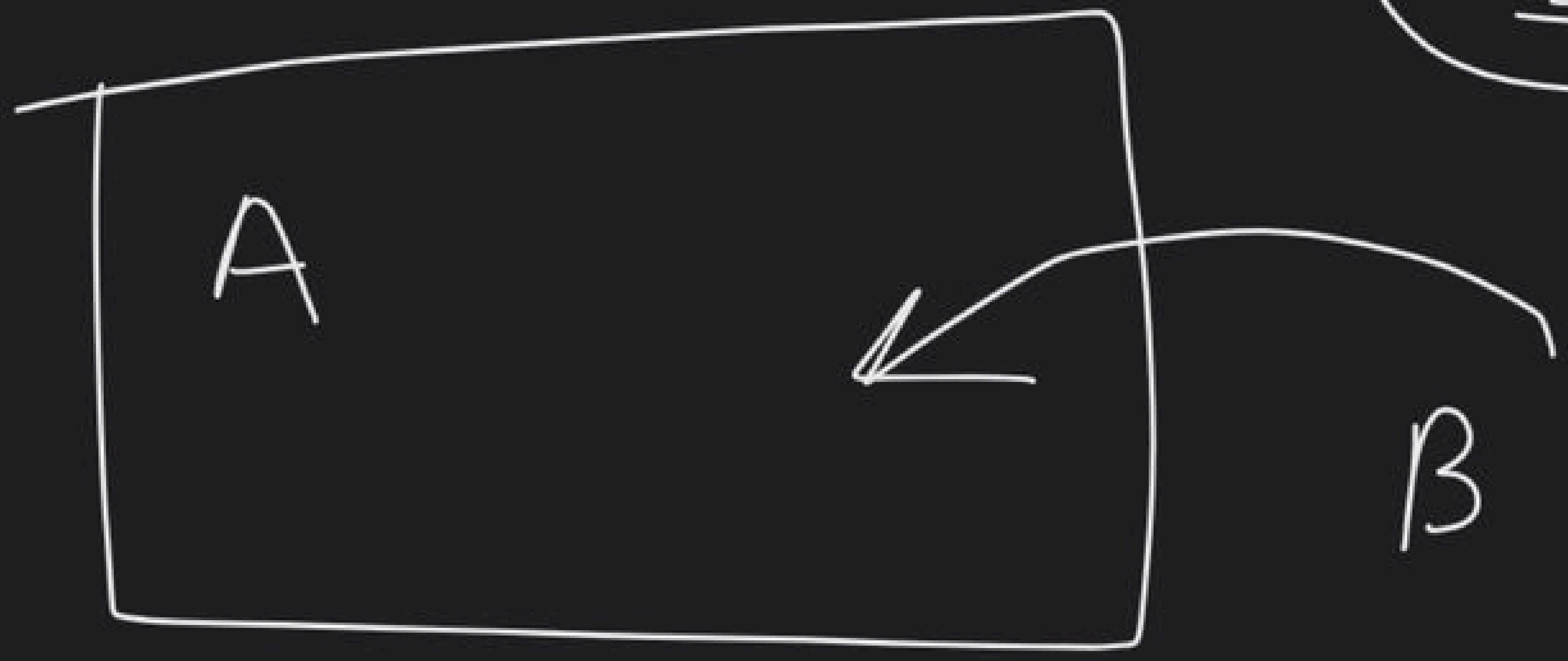
$$\lambda = \frac{V_{avg}}{\sqrt{2}\,\pi\,\sigma^2\,V_{avg}\,N^*} = \frac{1}{\sqrt{2}\,\pi\,\sigma^2\,N^*}$$



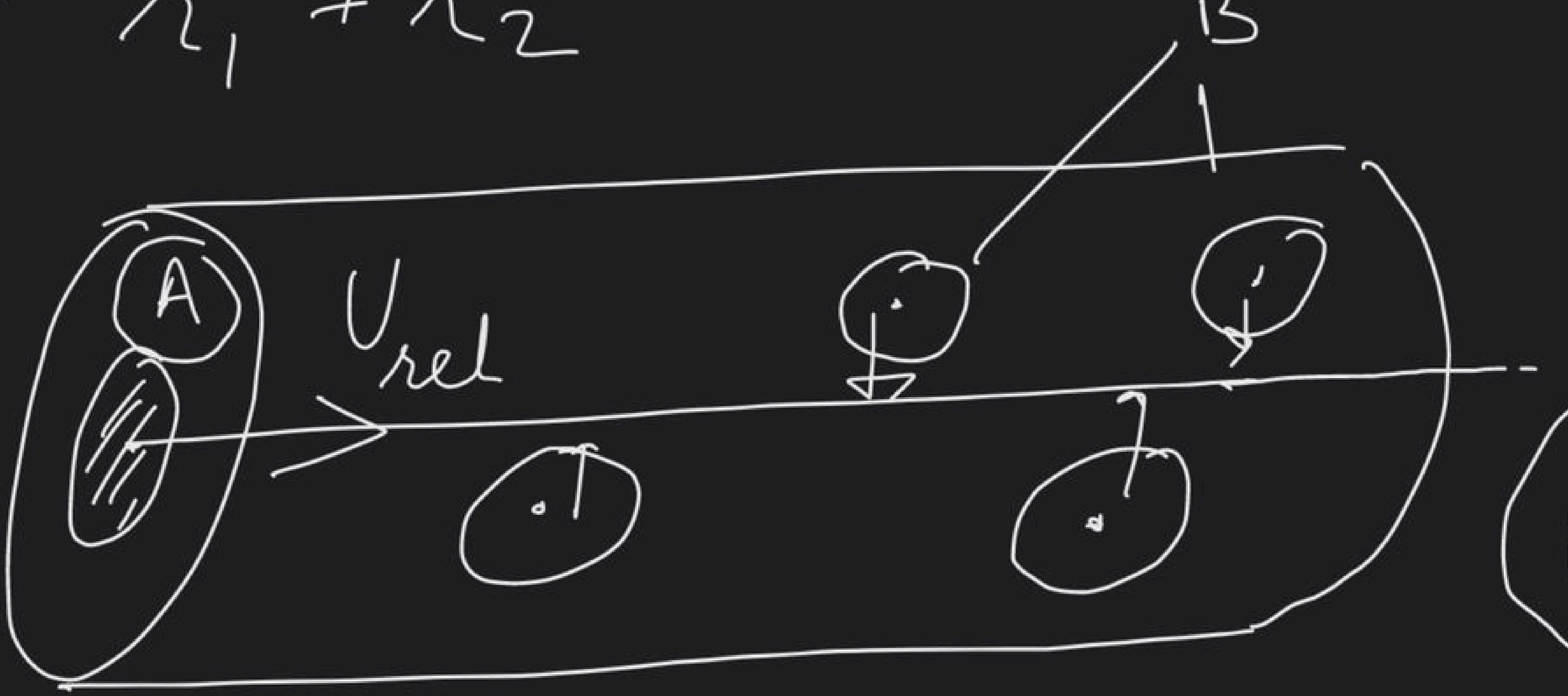
$A - A \rightarrow Z_{11}$

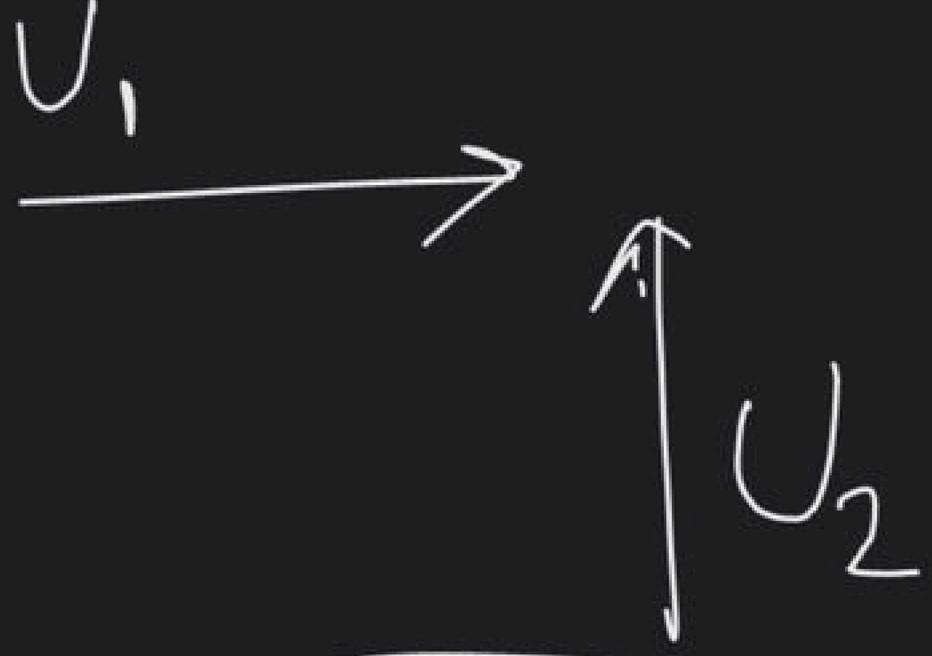
$B - B \rightarrow Z_{11}$

$A - B$



$\sigma = r_1 + r_2$





$$\boxed{U_{rel} = \sqrt{u_1^2 + u_2^2}}$$

$$= \sqrt{\frac{8RT}{\pi}\left(\frac{1}{M_1} + \frac{1}{M_2}\right)}$$

no. of molecules of B $= \underline{\pi \sigma^2 U_{rel}} \cdot N^*_B$

Total

Total no of Collision bet^n A & B per sec $= \pi \sigma^2 U_{rel} N_B^* \times N_A$

Total no of collision per sec per unit volume betn A & B $= \pi \sigma^2 U_{rel} N_B^* N_A^*$

$= Z_{12}$

$$Z_1 = \underline{\sqrt{2}\,\pi\sigma^2}\, \bar{U}_{avg} N^*$$

$$Z_{11} = \frac{1}{\sqrt{2}}\pi\sigma^2 U_{avg} (N^*)^2$$

$$= \frac{1}{2} Z_1 N^*$$

$$\lambda = \frac{1}{\sqrt{2}\pi\sigma^2 N^*} = \frac{U_{avg}}{Z_1}$$

$$U_{avg} \propto \sqrt{T}$$

betn A & B

$$Z_1 = \pi\sigma^2 U_{rel} N_B^*$$

$$Z_{12} = \pi\sigma^2 U_{rel} N_A^* N_B^*$$

Effect of p, T & V on Z_1, ...

$$\boxed{N^* = \frac{N}{V}}$$

$$pV = \frac{N}{N_A} RT$$

$$p = \frac{N}{V} \frac{R}{N_A} T$$

$$\boxed{N^* = \frac{p}{kT}}$$

$Z_1 \propto \sqrt{T}\ \dfrac{P}{T}$

$Z_1 \propto \dfrac{P}{\sqrt{T}}$

$Z_{11} \propto \dfrac{P^2}{T^{3/2}}$

$\lambda \propto \dfrac{T}{P}$

Q. With temp at const V

T increases — Z_1, Z_{11}, λ

(A) I I I

(B) D D D

(C) I I D

(D) None

(E) D D I

I I C

Since $P \propto T$

$Z_1 \propto \sqrt{T}$

$Z_{11} \propto \sqrt{T}$

$\lambda = \text{Const}$

J-M

S-1

O-II

(II) With Temp at const P

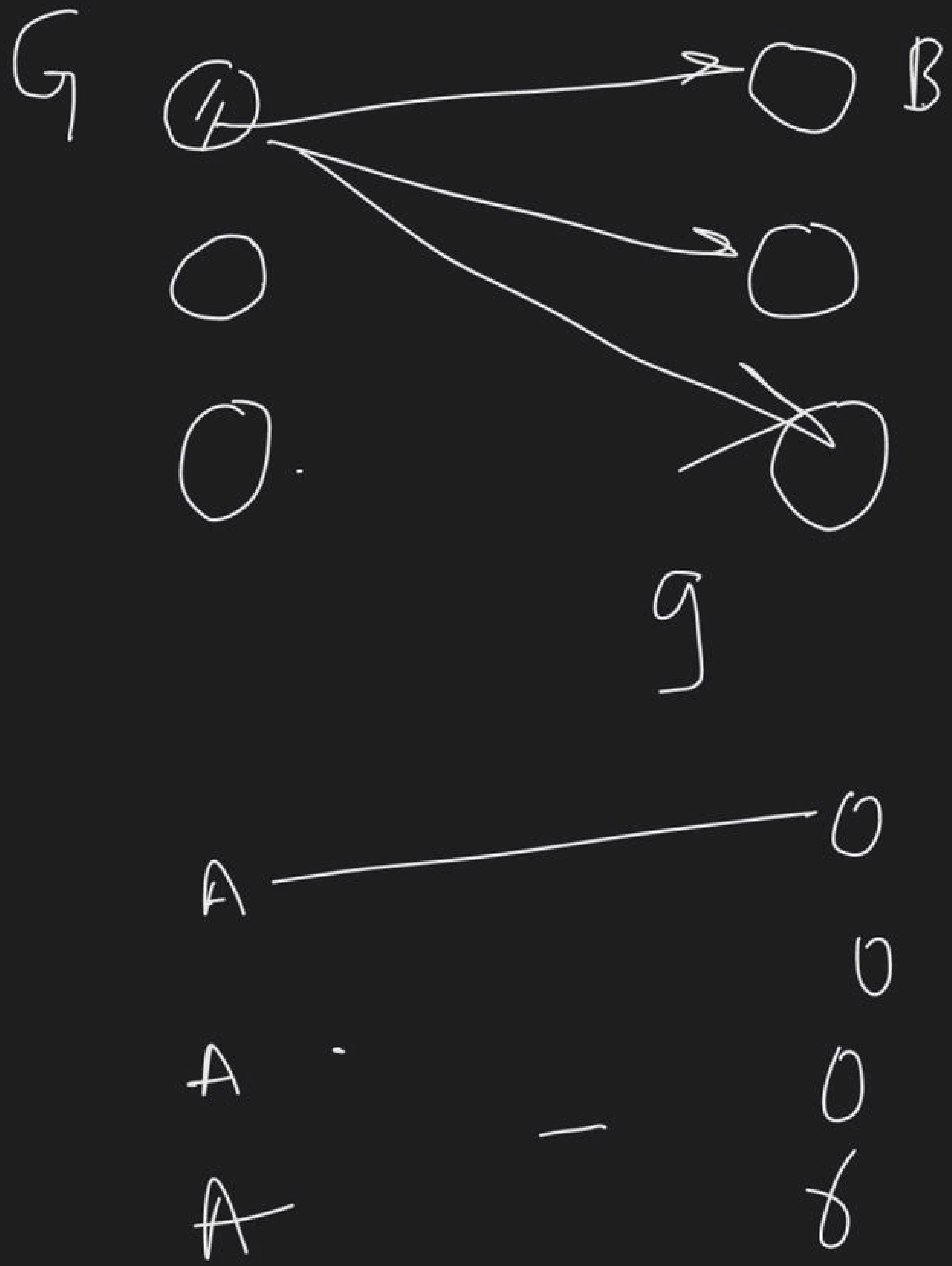
$T \uparrow$ $\quad Z_1 \propto \frac{1}{\sqrt{T}} \downarrow$

$Z_{11} \propto \frac{1}{T^{3/2}} \downarrow$

$\lambda \propto T \uparrow$

$T \uparrow \quad V \uparrow$

$\sqrt{2}$


G
B
g
A
A
A