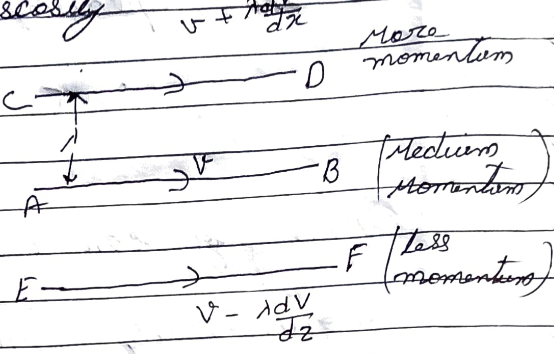
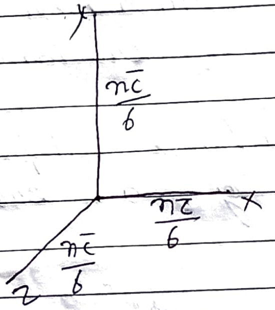
B.Sc Part - I

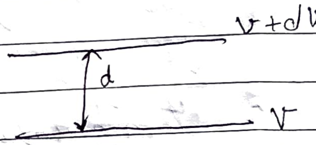
30/6/21

TRANSPORT OF MOMENTUM ie VISCOSITY

The layer moving faster exert momentum to the lower moving layer to bring equillibrium state, This gives rise to the phenomen of viscosity







velocity Gradeent $= \frac{v + dV - V}{}$

velocity gradient $= \frac{dV}{dZ}$

$n = \frac{N}{V} \Rightarrow N = nV = nAl$

$(\because l = \bar{c}t$

$\Rightarrow N = nA\bar{c}t$

$\Rightarrow \frac{N}{At} = n\bar{c}$

$\bar{c} = \sqrt{\frac{8KT}{\pi m}}$ Average velocity

$\Rightarrow$ No of particle moving on layers AB per unit area per unit time $= \frac{n\bar{c}}{6}$

$$\Rightarrow \boxed{\frac{N}{6At} = \frac{n\bar{c}}{6}} \longrightarrow (1)$$

Momentum carried by particles on layer AB per unit area per unit time =

$$\frac{n\bar{c}}{6} mV$$

The momentum carried downward by the molecules crossing unit area of AB per sec from CD = mass x velocity

$$P_1 = \frac{1}{6} mn\bar{c} \left(V + \lambda \frac{dV}{dz} \right) \quad \text{—— (2)}$$

Similarly momentum carried upward

$$P_2 = \frac{1}{6} mn\bar{c} \left(V - \lambda \frac{dV}{dz} \right) \quad \text{—— (3)}$$

By molecules, crossing AB per sec from EF,

⇒ Net momentum transferred per unit area per unit time from the layer CD towards the layer EF,

$$\Delta P = P_1 - P_2 \quad \text{—— (4)}$$

Put the values from eqn (2) and (3) in eqn (4)

$$\Delta P = \frac{1}{6} mn\bar{c} \left(V + \lambda \frac{dV}{dz} \right) - \frac{1}{6} mn\bar{c} \left(V - \lambda \frac{dV}{dz} \right)$$

$$\Rightarrow \Delta P = \frac{1}{3} mn\bar{c} \lambda \frac{dV}{dz} \quad \text{—— (5)}$$

According to Newton's II law

$$F = \frac{\Delta P}{\Delta t} \quad \text{—— (6)}$$

and $$F = \eta A \frac{dv}{dz} \quad \text{—— (7)}$$

comparing eqn (6) and eqn (7)

$$\Rightarrow \frac{\Delta P}{\Delta t} = \eta A \frac{dv}{dz}$$

Momentum per unit area $\frac{\Delta P}{A \Delta t} = \eta \frac{dv}{dz}$ —— (8)

From eqn (5) and eqn (8)

$$\Rightarrow \frac{1}{3} m n \bar{c} \lambda \frac{dv}{dz} = \eta \frac{dv}{dz}$$

$\Rightarrow$ co-efficient of viscosity $\boxed{\eta = \frac{1}{3} m n \bar{c} \lambda}$

Also we know that

$$\lambda = \frac{1}{\sqrt{2} \pi n d^2}$$

$$\Rightarrow \boxed{\eta = \frac{1}{3\sqrt{2}} \frac{m \bar{c}}{\pi d^2}}$$

$\because \bar{c} \propto \sqrt{T}$

$\Rightarrow \eta \propto \sqrt{T}$

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