Specific heat of gases

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a) Monoatomic gas

Energy associated with each degree of freedom $= \frac{1}{2}kT$

$\frac{3}{2}kT$

Energy associated with 1 Mole of gas

$$U = \frac{3}{2}KT \times N = \frac{3}{2}RT$$

$$C_V = \frac{dU}{dT} = \frac{3}{2}R$$

$$C_p - C_V = R$$

$$\Rightarrow C_p = \frac{5}{2}R$$

$$\gamma = \frac{C_p}{C_V} = \frac{5/2}{3/2}$$

$$\boxed{\gamma = 1.67}$$

(b) Diatomic gas

The energy associated per molecule $= 5 \times \frac{1}{2} kT$

Energy associated with one mole of gas

$$U = \frac{5}{2} kT \times N = \frac{5}{2} RT$$

$$C_v = \frac{dU}{dT} = \frac{5}{2} R$$

$$C_p = R + C_v = \frac{7}{2} R$$

$$\boxed{\gamma = 1.4}$$

(c) Triatomic gas

$6 \rightarrow \gamma = 1.33$

$7 \rightarrow \gamma = 1.28$

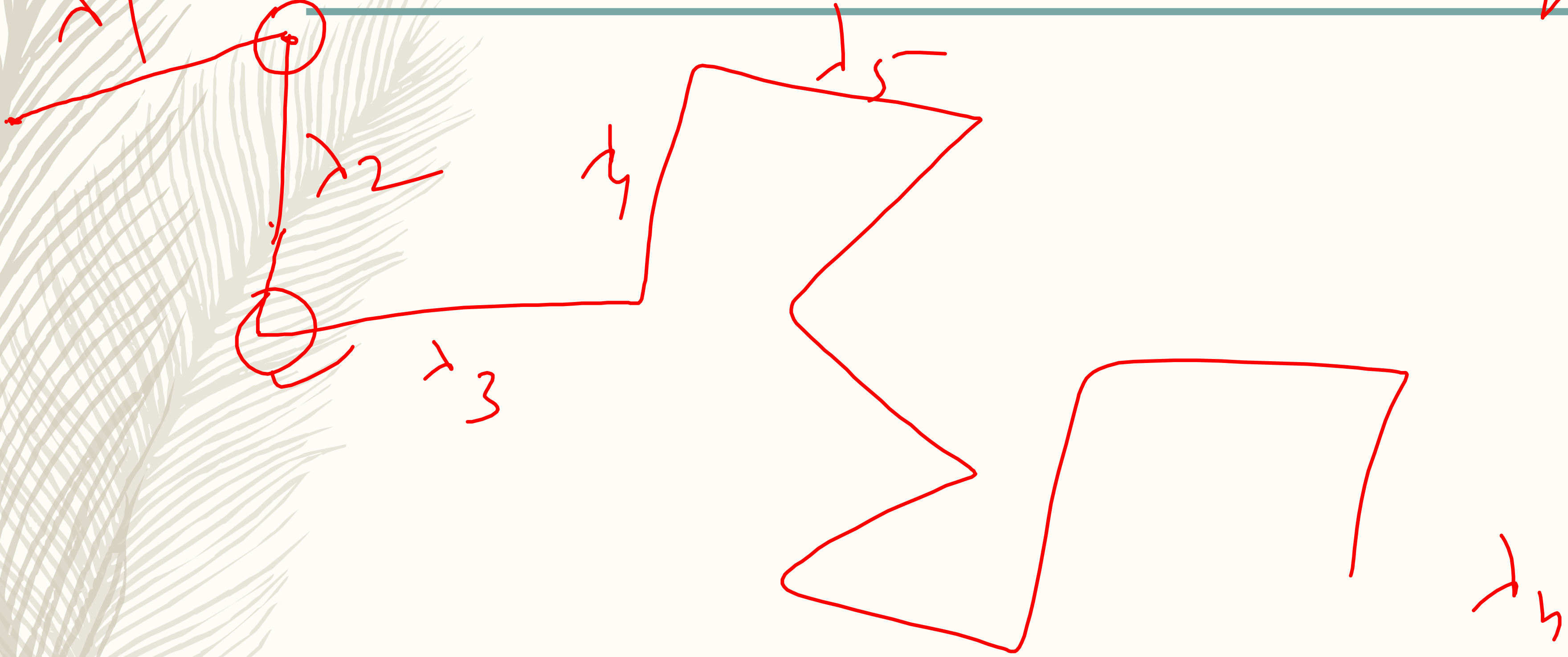
(d) Poly atomic gas

n

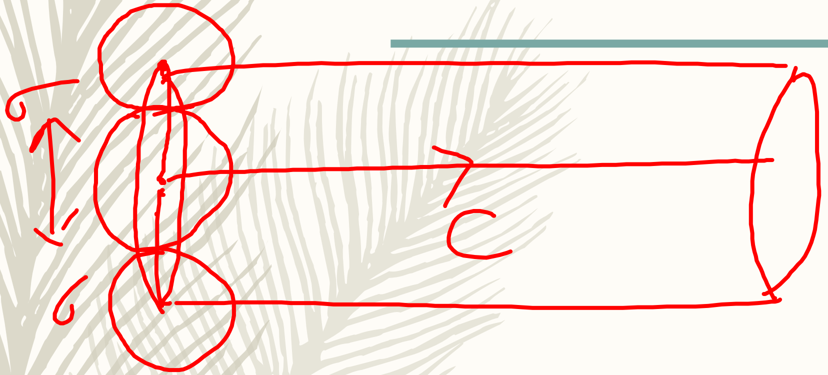
$$\boxed{\gamma = 1 + \frac{2}{n}}$$

Mean free path

$$\lambda = \frac{\lambda_1 + \lambda_2 + \lambda_3 + \dots \lambda_n}{n}$$



Expression for mean free path



The no of collisions made by the moving molecule in 1 sec

$$N = \pi \sigma^2 c n \quad - (1)$$

σ

$\pi \sigma^2$

c

$n \rightarrow$ no of molecule per unit volume

$$\lambda = \frac{\text{Total distance travelled in 1 sec}}{\text{No of collisions made by mol in 1 sec}}$$

$$= \frac{c}{\pi \sigma^2 n c}$$

$$\boxed{\lambda = \frac{1}{\pi \sigma^2 n}} \quad \text{— (2)}$$

$$\boxed{\lambda = \frac{1}{\sqrt{2}\, \pi \sigma^2 n}} \quad \text{— (3)}$$

$m \rightarrow$ mass of the molecule

$mn \rightarrow$ mass per unit volume

λ/ density ρ

$mn = \rho$

$\Rightarrow n = \frac{\rho}{m}$

$$\boxed{\lambda = \frac{m}{\sqrt{2}\pi\sigma^2\rho}} \quad \text{--- (4)}$$

$$P = \frac{1}{3}\rho c^2 \quad \text{--- (5)}$$

$$c^2 = \frac{3kT}{m}$$

$$P = \frac{1}{3}\rho \times \frac{3kT}{m}$$

$$= \frac{1kT}{m} \quad \Rightarrow \frac{m}{\rho} = \frac{kT}{P}$$

$$\boxed{\lambda = \frac{kT}{\sqrt{2}\pi\sigma^2 P}} \quad \text{--- (6)}$$

Distribution of free paths

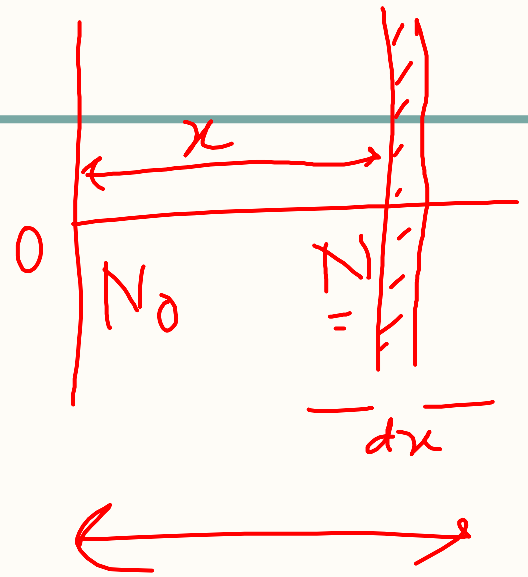
Collisional probability

$P_c\,dx$

$dN = N \times$ Prob. of a mol. for collision

$= -N P_c\,dx$

$$\Rightarrow \frac{dN}{dx} = -N P_c \quad \text{--- (1)}$$



$$\frac{dN}{N} = -P_c\, dx$$

$$\int_{N_0}^{N} \frac{dN}{N} = -P_c \int_0^x dx$$

$$\Rightarrow \log \frac{N}{N_0} = -P_c x$$

$$N = N_0 e^{-P_c x} \quad \text{--- } (2)$$

Differentiating

$$dN = -P_c N_0 e^{-P_c x} dx \quad \text{--- } (3)$$

$$\lambda = \frac{\text{Sum of all free paths for all } N_0 \text{ molecules}}{\text{Total no of mol}}$$

$$\lambda = \frac{1}{N_0} \int_0^\infty x\, dN$$

$$= \frac{1}{N_0} \int_0^\infty P_c N_0 x\, e^{-P_c x} dx$$

$$= P_c \int_0^\infty x\, e^{-P_c x} dx$$

$$\boxed{\lambda = \frac{1}{P_c}} \quad \text{--- } (4)$$

$$\boxed{N = N_0 e^{-x/\lambda}} \quad \text{— } 5$$

$$\frac{dN}{N} = -\frac{dx}{\lambda}$$

Transport Phenomena

1. Viscosity
2. Conduction
3. Diffusion

Thankyou