

CONCEPT: MEAN FREE PATH

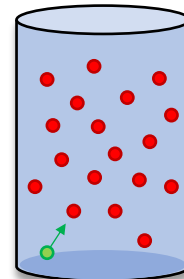
- **Mean Free Path:** Average (mean) distance gas particles travel before _____ with another particle.

- Analogy: If you walked through a crowded room, the average distance you walk before bumping into someone.

$$\lambda = \text{_____} = \text{_____}$$

- t_{avg} = average time between collisions

- r = radius of particles. If not given, assume $r = 0.5 \times 10^{-10}$ (monoatomic), $r = 1 \times 10^{-10}$ m (diatomic)



EXAMPLE: Calculate **a)** the mean free path of oxygen molecules in the air at STP; **b)** the average time between molecule collisions. The radius of oxygen molecules is approximately 1.5×10^{-10} m, and they move with an average speed 450 m/s.

THERMO EQs & CONSTANTS

$$PV = nRT \quad \text{OR} \quad PV = Nk_B T$$

$$k_B = 1.38 \times 10^{-23} \frac{J}{K}$$

$$R = 8.314 \frac{J}{mol \cdot K}$$

PROBLEM: Laboratory environments can achieve pressures of 3.5×10^{-13} atm and temperatures of 300K. Calculate the mean free path (in km) of air molecules, which you can assume are diatomic.

- A) 1.04×10^{-32} km
- B) 6.65 km
- C) 660 km
- D) 8.22×10^{-10} km

IDEAL GAS EQs & Constants
$PV = nRT = Nk_B T$ $\lambda = v_{avg} t_{avg} = \frac{V}{\sqrt{2} \cdot 4\pi r^2 N}$ $r_{monoatomic} = 0.5 \times 10^{-10} \text{ m}$ $r_{diatomic} = 1.0 \times 10^{-10} \text{ m}$
$R = 8.314 \frac{\text{J}}{\text{mol K}}$ $k_B = 1.38 \times 10^{-23} \frac{\text{J}}{\text{K}}$ $N_A = 6.02 \times 10^{23}$
CONVERSIONS
$1\text{L} = 0.001 \text{ m}^3$ $1 \text{ atm} = 1.01 \times 10^5 \text{ Pa}$

PROBLEM: The mean free path of nitrogen particles at STP is 8×10^{-8} m. What is the radius of the nitrogen particles?

IDEAL GAS EQs & Constants
$PV = nRT = Nk_B T$ $\lambda = v_{avg} t_{avg} = \frac{V}{\sqrt{2} \cdot 4\pi r^2 N}$
$R = 8.314 \frac{\text{J}}{\text{mol K}}$ $k_B = 1.38 \times 10^{-23} \frac{\text{J}}{\text{K}}$ $N_A = 6.02 \times 10^{23}$ STP: T = 273K, P = 1.01×10^5 Pa