Effusion

- Molecular effusion: the gas is almost unaffected by the presence of the hole except that molecules near the hole may fly through it.

- condition for a circular hole:

$$a \ll \lambda .$$

radius of the hole

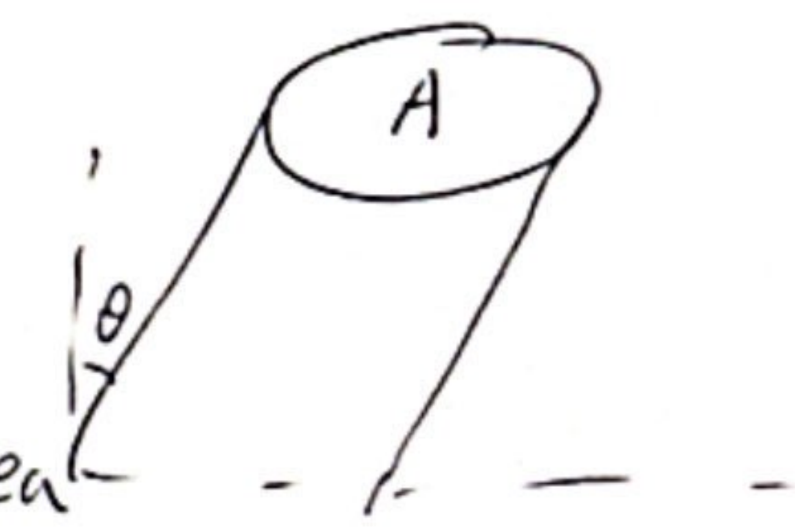
mean free path

Average distance travelled between collisions.

consider the particles travelling in the directions close to (θ, φ). the number density

$$n \cdot f(v)\, dv \cdot \frac{\sin\theta \, d\theta \, d\varphi}{4\pi}$$

$$dN = n f(v)\, dv \, \frac{\sin\theta \, d\theta \, d\varphi}{4\pi} \cdot A v t \cos\theta$$



Momentum received by the wall. per area per time

$$\frac{dN \, m v \cos\theta}{A t} = n f(v)\, dv \, \frac{\sin\theta \, d\theta \, d\varphi}{4\pi} \, v \cos\theta \, m v \cos\theta$$

The total momentum exchanged is the doubled.

$$p = 2nm \int_0^\infty v^2 f(v)\, dv \int_0^{\pi/2} \sin\theta \cos^2\theta \, d\theta \int_0^{2\pi} \frac{d\varphi}{4\pi}$$

$\theta : [0, \frac{\pi}{2}]$ because molecules approach the wall from only one side.

$$p = \frac{nm}{3} \langle v^2 \rangle .$$

- Effusion Calculation

$$\text{rate} = \frac{n \times V}{t}$$

$$= n f(v)\,dv \, \frac{\sin\theta \, d\theta \, d\varphi}{4\pi} \, \frac{A v t \cos\theta}{t}$$

the total flux. (total rate per area)

$$\Phi = n \int_0^{\infty} v f(v)\,dv \int_0^{\frac{\pi}{2}} \sin\theta \cos\theta \, d\theta \int_0^{2\pi} \frac{d\varphi}{4\pi}$$

$$= n \cdot \langle v \rangle \cdot \frac{1}{2} \cdot \frac{1}{2}$$

$$= \frac{n}{4} \langle v \rangle$$

- Effusion between Regions at Different Temperature

effusion rate from 1 to 2

$$\frac{1}{4} A n_1 \langle v_1 \rangle$$

effusion rate from 2 to 1

$$\frac{1}{4} A n_2 \langle v_2 \rangle.$$

Region 1 maintained at T_1

2 at T_2.

if these 2 rates don't agree, there is a flow.

At a dynamic equilibrium:

$$n_1 \langle v_1 \rangle = n_2 \langle v_2 \rangle.$$

since $\langle v \rangle \propto \sqrt{T}$.

$$n_1 \sqrt{T_1} = n_2 \sqrt{T_2}$$

If the hole is large, then gas continues to move until the pressure on both sides is balanced.