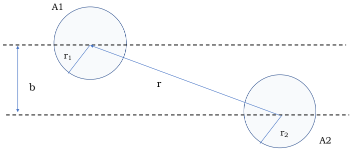
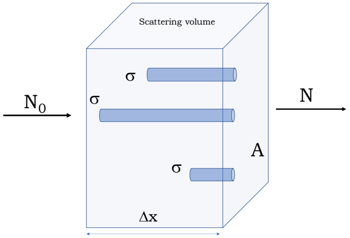


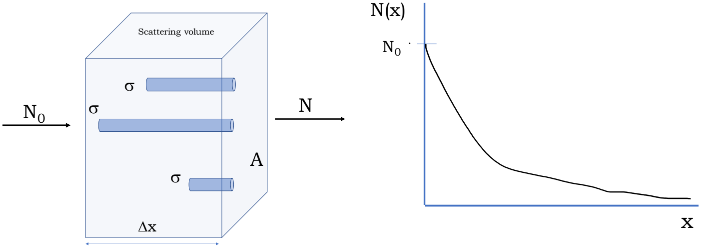
Some definitions

- Impact parameter b: Perpendicular distance between the center of two molecules
- r_1 and r_2 are the radii of two molecules.
- Collision takes place when $b \leq (r_1 + r_2)$. The closest distance between the centre of molecule: $d = r_1 + r_2$.
- Collisional cross section is the area exposed by one particle to the other particle for interaction. Denoted by σ and has unit of area.
- The circular area around the centre of A2, when particles A1 come and will get deflected (interact/collide): $\sigma = \pi\ (r_1 + r_2)^2$. Collision takes place when $b \leq (r_1 + r_2)$

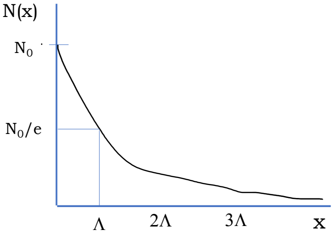
Particle Flux



- For simplicity let us consider 1D model along X-axis. Let us calculate a fraction of total cross section to total area.
- $\frac{\Sigma\sigma}{A} = \frac{n\sigma\Delta x A}{A} = n\ \sigma\ \Delta$x.
- where n is the number density and $\Delta x A =$ V is the volume.
- If N molecules impinge per second the area A of Volume V, then the fraction that suffers collision after a path length Δx : $\frac{\Delta N}{N} = \frac{\Sigma\sigma}{A} = n\ \sigma\ \Delta$x.



- In differential form and taking negative sign as particles are deflected or lost: $\frac{dN}{N}$ = - $n\ \sigma\ \Delta$x.
- Integrating: $N(x) = N_0\ e^{-n\sigma x}$
- This is the particle flux $N(x)$ after a path length x through the collision volume.



- Mean free path (Λ) is the path length which a particle A1 passes on an average without a collision.
- $\Lambda = \frac{\int_0^\infty xN(x)dx}{\int_0^\infty N(x)dx} = \frac{\int_0^\infty xe^{-n\sigma x}dx}{\int_0^\infty e^{-n\sigma x}dx} = \frac{1}{n\sigma}$
- Now, $N(x) = N_0\ e^{-n\sigma x} = N_0\ e^{-x/\Lambda}$
- Hence, mean free path Λ represents that path length after which the number of particles in the incident beam has decreased to $1/e$ of its initial value.

- $\tau = \frac{\Lambda}{\langle v \rangle} = \frac{1}{n\sigma \langle v \rangle}$
- If v_1 and v_2 are velocities of A1 and A2, then the mean velocity is replaced by the relative velocity $\overline{\Delta v} = \overline{v_1 - v_2} = \sqrt{2\overline{v^2}}$
- So, $\tau = \frac{1}{n\sigma\sqrt{2\overline{v^2}}}$

At atmospheric pressure $P = 10^5$ Pa, the number density of the molecules in the atmosphere $n \sim 3 \times 10^{19}\ cm^{-3}$. The elastic collision cross section $\sigma \sim 45 \times 10^{-16}\ cm^2$.
Mean free path $\Lambda = \frac{1}{n\sigma} \sim 7 \times 10^{-6}$ cm $= 70$ nm.
Mean velocity $\langle v \rangle \sim 475$ m/s at $T = 300$ K.
Mean flight time between two collisions: $\tau = \frac{\Lambda}{\sqrt{s\langle v^2 \rangle}} = \Lambda\,\sqrt{\frac{m}{6KT}} = 1.1 \times 10^{-10}$ sec.