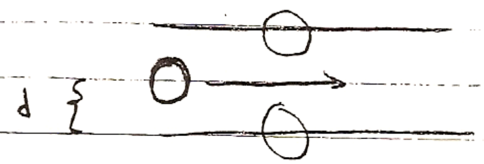
Collisions

calculate frequency of collisions z



collide with everything inside area πd^2

~~d diameter of molecule~~

$\sigma = \pi d^2$ collision cross section

average speed $\bar{c}$

V' volume in which collision could occur = (length) · (area)

$\ell = \bar{c}\,\Delta t$, area $= \pi d^2 = \sigma$

moles, fraction of collision: $N\left(\frac{V'}{V}\right)$

divide by Δt get collision frequency

collisions during time period Δt $\qquad \bar{c}\,\Delta t\,\sigma \frac{N}{V}$

collisions per time Δt $\qquad \bar{c}\,\sigma \frac{N}{V}$ $\qquad m\,s^{-1}\; m^2\; \frac{\#}{m^3}$

$\bar{c}$ should be average relative speed $\qquad$ because other molecules ~~are~~ moving ~~too~~ also

$\bar{c} \rightarrow \sqrt{2}\,\bar{c} \sim 1.41\,\bar{c}$

collision frequency:
→ for single molecule

$$z = \frac{\sqrt{2}\,\sigma \bar{c} N}{V}$$

→ for N molecules $\quad Nz$ but overcount so $\frac{Nz}{2}$ since each collision is for 2 molecules

→ N molecules per volume V $\quad \frac{Nz}{2V}$

Collisions per unit volume per time

$$Z_{AA} = \frac{\sigma \bar{c}}{\sqrt{2}} \frac{N^2}{V^2}$$

$$\bar{c} = \left(\frac{8kT}{\pi m}\right)^{1/2}$$

$$Z_{AA} = \sigma \left(\frac{N}{V}\right)^2 \left(\frac{4kT}{\pi m}\right)^{1/2}$$

same type of molecules

for two types of molecules

$$Z_{AB} = \pi d_{AB}^2 \left(\frac{8kT}{\pi \mu}\right)^{1/2} \frac{N_A N_B}{V^2}$$

where $d_{AB} = \frac{1}{2}(d_A + d_B)$

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Properties which may depend on number of collisions imply that possible to calculate molecular diameter

? $d \approx 280\ pm = 2.8\ \AA$ $\quad Z \approx 5 \times 10^{34}\ s^{-1}\ m^{-3}$

$\approx 5 \times 10^{28}\ s^{-1}\ cm^{-3}$

- Mean Free Path

Calculate mean free path λ

molecule at speed $\bar{c}$ collides frequency z

time between collisions $\frac{1}{z}$

use units → $\quad (\frac{m}{s}) \quad (\frac{s}{collision})$

$$\lambda = (\bar{c})\left(\frac{1}{z}\right)$$

$$\lambda = \frac{(\bar{c})}{z} = \frac{V\ (\bar{c})}{\sqrt{2}\,\sigma \bar{c} N}$$

$$\lambda = \frac{1}{\sqrt{2}\,\sigma (N/V)}$$

$$\lambda = \frac{1}{\sqrt{2}\,\sigma (P/kT)}$$

$$\lambda = \frac{kT}{\sqrt{2}\,\sigma P}$$

$$\lambda = \frac{kT}{\sqrt{2}\,\sigma P}$$