Principles of Physical Chemistry

Properties of Gases

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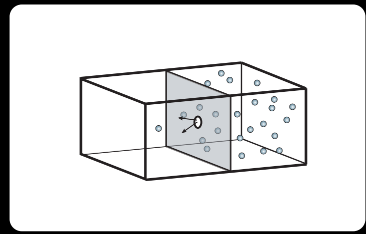
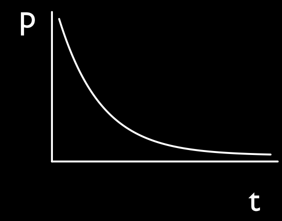
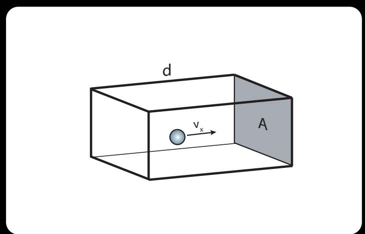
Effusion





Effusion



Effusion

$$
\begin{aligned}
\langle V \rangle &= \int_0^\infty V P(v_x) dv_x \\
&= A\Delta t \int_0^\infty v_x \sqrt{\frac{m}{2\pi k_B T}} \exp\left(\frac{-mv_x^2}{2k_B T}\right) dv_x
\end{aligned}
$$

$$\int_0^\infty e^{-x^2}dx = \frac{\sqrt{\pi}}{2} \qquad \int_0^\infty x^3 e^{-x^2}dx = \frac{1}{2}$$

$$\int_0^\infty x e^{-x^2}dx = \frac{1}{2} \qquad \int_0^\infty x^4 e^{-x^2}dx = \frac{3\sqrt{\pi}}{8}$$

$$\int_0^\infty x^2 e^{-x^2}dx = \frac{\sqrt{\pi}}{4} \qquad \int_0^\infty x^5 e^{-x^2}dx = 1$$

Effusion

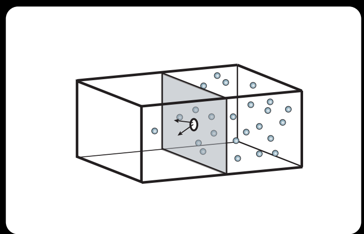
$$\begin{aligned}\langle V\rangle &= \int_0^\infty V P(v_x) dv_x \\ &= A\Delta t \int_0^\infty v_x \sqrt{\frac{m}{2\pi k_B T}} \exp\left(\frac{-m v_x^2}{2k_B T}\right) dv_x\end{aligned}$$

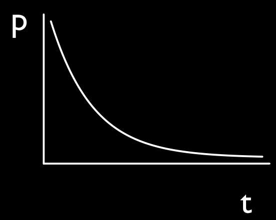
$$\int_0^\infty x e^{-x^2} dx = \frac{1}{2}$$

$$\langle V\rangle = A\Delta t \left(\frac{k_B T}{2\pi m}\right)^{1/2}$$

$$z_{\mathrm{wall}} = \frac{p}{k_B T}\left(\frac{k_B T}{2\pi m}\right)^{1/2} = \frac{p}{(2\pi m k_B T)^{1/2}}$$

Effusion



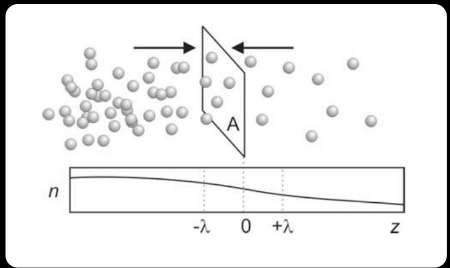


Graham's law of effusion: $\frac{dN}{dt} \propto \frac{1}{\sqrt{m}}$

Ideal Gas Transport Properties

Property	Transported Quantity	Kinetic Theory	Units
Diffusion	Matter	$D = \frac{1}{3}\lambda\langle v\rangle$	$m^2 s^{-1}$
Thermal Conductivity	Energy	$\kappa = \frac{1}{3}\lambda\langle v\rangle C_V [A]$	$J\ K^{-1}\ m^{-1}\ s^{-1}$
Viscosity	Momentum	$\eta = \frac{1}{3}\rho_N m\lambda\langle v\rangle$	$kg\ m^{-1}\ s^{-1}$

Diffusion in a Gas

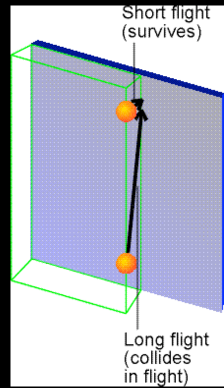


$$J_z = -D\frac{d\rho_N}{dz}$$

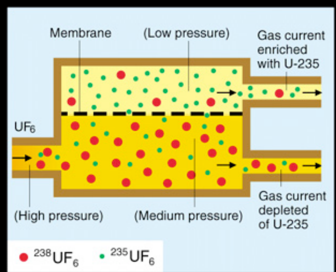
$$D = \frac{1}{3}\lambda\langle v\rangle$$

$$\langle v\rangle = \sqrt{\frac{8k_BT}{\pi m}}$$

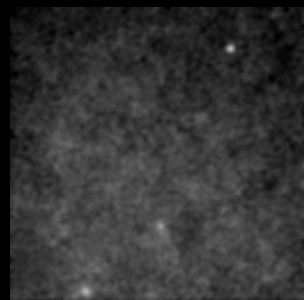
Diffusion in a Gas



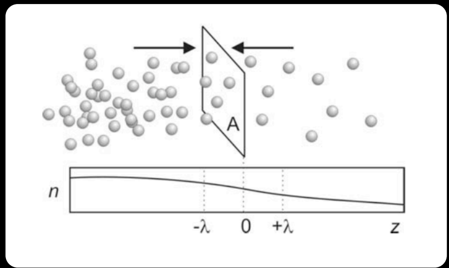
Diffusion in a Gas



http://www.euronuclear.org



Diffusion in a Gas

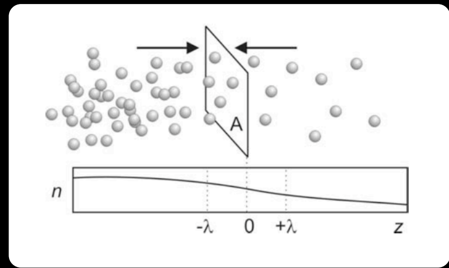


$$J_z = -D\frac{d\rho_N}{dz}$$

$$D = \frac{1}{3}\lambda \langle v \rangle$$

$$\langle v \rangle = \sqrt{\frac{8k_BT}{\pi m}}$$

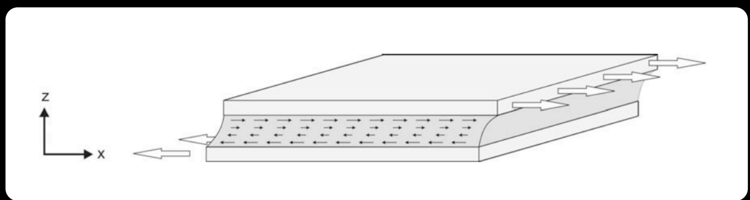
Thermal Conductivity in a Gas



$$J_z = -\kappa\frac{dT}{dz}$$

$$\kappa = \frac{1}{3}\lambda \langle v \rangle C_V\,[A]$$

Gas Viscosity



$$J_z = -\eta\frac{dv_x}{dz}$$

$$\eta = \frac{1}{3}\rho_N m\lambda \langle v \rangle$$

Ideal Gas Transport Properties

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Diffusion	Matter	$D = \frac{1}{3}\lambda \langle v \rangle$	m^2s^{-1}
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Course Summary

Ideal & Real gases

- pV=nRT
- Virial Expansion
- Compression Factor

Kinetic theory of gases

- Derivation
- Classical Equipartition, predicting Cv

Maxwell Boltzmann

- Derivation
- Collision frequencies
- Mean free path

Applications

- Effusion
- Diffusion
- Thermal Conductivity
- Viscosity