物理

$\overline{\quad 200m \quad}$ 20°C 時.

$\Delta L = \underset{\mathrm{I}}{\alpha} L_0 \Delta T$

$12 \times 10^{-6} \ (C^\circ)^{-1}$

$-40^\circ C$ (調 $40^\circ C$)

$\Delta L = 12 \times 10^{-6} \times 200 \times -40 \ (m)$

72 L 的 汽油

$\Delta V = 3\alpha V_0 (40^\circ C - 20^\circ C)$

$= 36 \times 10^{-6} \times 72 \times 20^\circ C$

$= 0.05 L$ ← 桶子

$\Delta V = \beta V_0 \Delta T$

$\simeq 1.3 L$. $\beta = 950 \times 10^{-6}$.

汽油

$5m \times 3m \times 2.5m \rightarrow 37.5 \ m^3$.

$\frac{37500 \ l}{24} = 1600$ mole 24 公升 的 空氣, 1 mole.

空氣 1mole 29 克.

因此 有 45 kg

$\overline{K}$ at 37°C

$\overline{K} = \frac{3}{2} kT =$ ~~#~~ 1.42×10^{-21} J (一顆平均動能).

1mole 的 動能 $6 \times 10^{23} \times 1.42 \times 10^{-21} = 3900$ J

$\frac{1}{2} m \overrightarrow{V_{rms}}^2 = \frac{3}{2} kT$ $V_{rms} = \sqrt{\frac{3kT}{m}}$

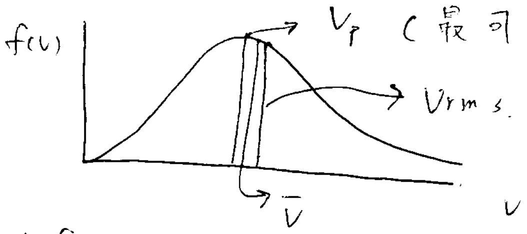
$m_{O_2} = 32 \times 1.66 \times 10^{-27}$ kg.

$= 5.3 \times 10^{-26}$.

O_2 $V_{rms} \cong 492$ m/s. ，用比例即可知 N_2 和其它氣体

N_2 $V_{rms} = 526$ m/s.

$$f(v) = 4\pi N \left(\frac{m}{2\pi kT}\right)^{3/2} v^2 e^{-\frac{mv^2}{2kT}}$$ 速度分布



$$\left.\frac{\partial f(v)}{\partial v}\right|_{v=v_p} = 0 = C(2v)e^{-\frac{mv^2}{2kT}} + Cv^2\left(-\frac{\cancel{2}m}{2kT}\right)2v\, e^{-\frac{mv^2}{2kT}}$$

$$2vCe^{-mv^2/2kT}\left(1 - \frac{mv^2}{2kT}\right) = 0.$$

$$V_p = \sqrt{\frac{2kT}{m}}$$

$$\bar{V} \cancel{N} = \frac{\int_0^\infty v f(v)\, dv}{N} = 4\pi\left(\frac{m}{2\pi kT}\right)^{3/2} \int_0^\infty v^3 e^{-\frac{mv^2}{2kT}} dv$$

$$= 4\pi\left(\frac{m}{2\pi kT}\right)^{3/2} \frac{1}{2} \int_0^\infty x e^{-\frac{mx}{2kT}} dx$$

$$d(xe^{ax}) = e^{ax}dx + xae^{ax}dx.$$

$$= 4\pi\left(\frac{m}{2k\pi T}\right)^{3/2} \frac{1}{2}\left[\underbrace{-\frac{2kT}{m} x e^{-\frac{mx}{2kT}}\Big|_0^\infty}_{0} + \int_0^\infty \frac{2kT}{m} e^{-\frac{mx}{2kT}} dx\right]$$

$$= 4\pi\left(\frac{m}{2\pi kT}\right)^{3/2}\left(\frac{2kT}{m}\right)^2 \frac{1}{2}.$$

$$\bar{V} = \sqrt{\frac{8kT}{m\pi}} \simeq 1.6\sqrt{\frac{kT}{m}}$$

$$f(v) = 4\pi N \left(\frac{m}{2\pi kT}\right)^{3/2} v^2 e^{-\frac{mv^2}{2kT}}$$

波茲曼統計

$$\left(\left(\frac{m}{2\pi kT}\right)^{1/2}\right)^{3} \Rightarrow 3\text{維}$$

對空間積分

三維動量積分而得.

He 10^6 粒子個數.

$$V_p = \sqrt{2kT/m} = 1.12\times10^3 \ m/s$$

$$\Delta N = f(v)\,\Delta v \simeq 4\pi N \left(\frac{m}{2\pi kT}\right)^{3/2} v^2 e^{-\frac{mv^2}{2kT}} \Delta v$$

$$\simeq 30000$$

$$\Delta N' = f(v')\,\Delta v \simeq 4\times10^{-37}$$ (即 v↑者比率極小)

Van der Waals gas

b. 每 mole gas volumn

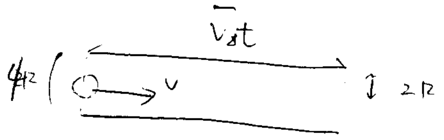
$$P(V - nb) = nRT$$

$$P\left(\frac{V}{n} - b\right) = RT \longrightarrow P = \frac{RT}{\left(\frac{V}{n} - b\right)} - a\left(\frac{n}{V}\right)^2$$

(考慮粒子間作用力)

$$P = \frac{RT}{\frac{V}{n} - b} - \frac{a}{\left(\frac{V}{n}\right)^2} \rightarrow \left(P + \frac{a}{\left(\frac{V}{n}\right)^2}\right) = \frac{RT}{\frac{V}{n} - b}$$

$$\cancel{P\ \frac{a}{\frac{V}{n}}} \quad \left(P + \frac{a}{\left(\frac{V}{n}\right)^2}\right)\left(\frac{V}{n} - b\right) = RT$$



半徑 R 以 v 運動

l_m 平均自由徑 $= \dfrac{\bar{v}\Delta t}{\frac{N}{V}\pi(2R)^2\,\bar{v}\,\Delta t} = \dfrac{1}{4\pi R^2\,(N/V)}$

考慮粒子自動 ⇒ 相對運動速度

$$l_m = \frac{1}{\sqrt{2}\,4\pi R^2\,(N/V)}$$

空氣的 $l_m = 900$ Å