IDEAL GAS

$$Z = \frac{1}{N!} Z_1^N$$

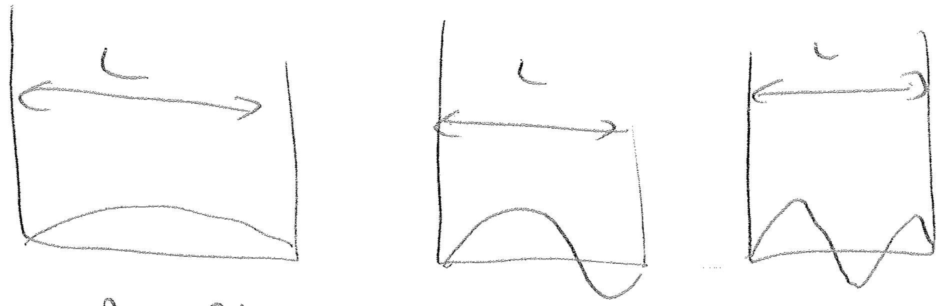
e ~~with~~ $E_1 = \underbrace{\frac{1}{2}mv^2}_{E_{tr}} + \underbrace{\frac{1}{2}kx^2 \ldots}_{E_{int}}$

$$Z = \sum_s e^{-E(s)/kT} = \sum_s e^{-E_{tr}(s)/kT} \sum_s e^{-E_{int}(s)/kT}$$

$$Z = Z_{tr} Z_{int}$$

STATES?

$\Delta x \Delta p \sim h$?



$\lambda_1 = 2L$ $\qquad \lambda_2 = \frac{2L}{2} = L$ $\qquad \lambda_3 = \frac{2L}{3}$

TRANSLATIONAL ENERGIES $\qquad p = \frac{h}{\lambda}$

$$E_n = \frac{p_n^2}{2m} = \quad h$$

$$p_n = \frac{h}{\lambda} = \frac{hn}{2L}$$

$$E_n = \frac{p_n^2}{2m} = \frac{n^2h^2}{8mL^2} = \frac{n^2h^2}{8mL^2}$$

$$z_{tr} = \sum_n e^{-E_n/kT} = \sum_n e^{-n^2h^2/8mL^2kT}$$

$$= \int_0^\infty e^{-n^2h^2/8mL^2kT}\,dn = \frac{\sqrt{\pi}}{2}\sqrt{\frac{8mkT}{h^2}}\;L$$

$$= \sqrt{\frac{2\pi mkT}{h^2}}\;L = \frac{L}{\Lambda}$$

$$l_Q = \sqrt{\xi} = \frac{h}{\sqrt{2\pi m k T}}$$

l_Q : QUANTUM LENGTH.

de BROGLIE WAVELENGTH OF PARTICLE OF MASS m
AT $E = kT$

N_2 @ 300K 1.9×10^{-11} m

DE BROGLIE VOLUME

$$V_Q = l_Q^2 = \left(\frac{h}{\sqrt{2\pi m k T}}\right)^3$$

$$Z_1 = \frac{V}{V_Q} Z_{int}$$

$$Z_{total} = \frac{1}{N!}\left(\frac{V Z_{int}}{V_Q}\right)^N$$

$$\ln Z = N[\ln V + \ln Z_{int} - \ln N - \ln V_Q + 1]$$

~~RSD~~

RESULTS

$$U = -\frac{1}{Z}\frac{\partial Z}{\partial \beta} = -\frac{\partial}{\partial \beta}[\ln Z]$$

$$= -\frac{\partial}{\partial \beta}\ln Z_{int} + N\frac{1}{V_Q}\frac{\partial V_Q}{\partial \beta}$$

$$V_Q = \left(\frac{h}{\sqrt{2\pi m}}\right)^3 \beta^{3/2}$$

$$= N\bar{E}_{int} + N\frac{3}{2}\frac{1}{\beta} = N\bar{E} + \frac{3}{2}NkT$$

$$F = -kT\ln Z = -NkT[\ln V + \ln Z_{int} - \ln N - \ln V_Q + 1)$$

$$= -NkT(\ln V - \ln N - \ln V_Q + 1] + F_{int}$$

$$P = -\left(\frac{\partial F}{\partial V}\right)_{T,N} = \left(\frac{NkT}{V}\right) = \frac{NkT}{V}$$

$$\cancel{S = -\left(\frac{\partial F}{\partial T}\right)_{V,N} = -\frac{\partial F_{INT}}{\partial T} + \frac{NkT}{V_Q}}$$

$$S = -\left(\frac{\partial F}{\partial T}\right)_{V,N} = -\left(\frac{\partial F}{\partial \beta}\right)\left(\frac{\partial \beta}{\partial T}\right)$$

$$= \frac{1}{kT^2}\frac{\partial}{\partial \beta}\left(NkT \ln \beta T \right)$$

$$=$$

$$\frac{\partial F}{\partial T} = -Nk\left[\ln V - \ln N - \ln V_Q + 1\right]$$

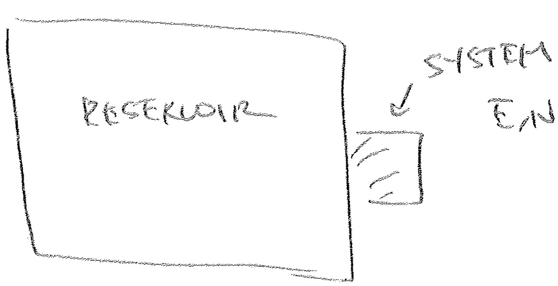
$$+ \boxed{NkT \frac{1}{V_Q}\frac{\partial V_Q}{\partial T}}$$

$$= -Nk\left[\ln\left(\frac{V}{NV_Q}\right) + \frac{5}{2}\right) NkT \frac{3}{2} - \frac{1}{T} - \frac{\partial F_{INT}}{\partial T}$$

$$S_{IK} = Nk \left[\ln \left(\frac{V}{N V_Q} \right) + \frac{5}{2} \right]$$

$$= Nk \left(\ln \left(\frac{V h^3}{N (2\pi m k T)^{3/2}} \right) + \frac{5}{2} \right.$$

GIBBS FACTOR



$$\text{GIBBS FACTOR} = e^{-[E(s) - \mu N(s)]/kT}$$

$\mathcal{Z}$ = GRAND PARTITION FUNCTION

$$= \sum_s e^{-[E(s) - \mu N(s)]/kT}$$

= GIBBS SUM.