

TOPIC : Entropy of Monoatomic gases

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$$S = k_B \ln(Z(N, V, T)) + k_B T \left(\frac{\partial \ln Z(N, V, T)}{\partial T} \right)_{N, V}$$

for
Canonical ensemble of Monoatomic gases

OR, $TS = E - A$

$$\Rightarrow S = - \frac{A}{T} + \frac{E}{T}$$

~~Already~~ $E \equiv$ Internal Energy

~~derived~~ $A \equiv$ Helmholtz Free energy

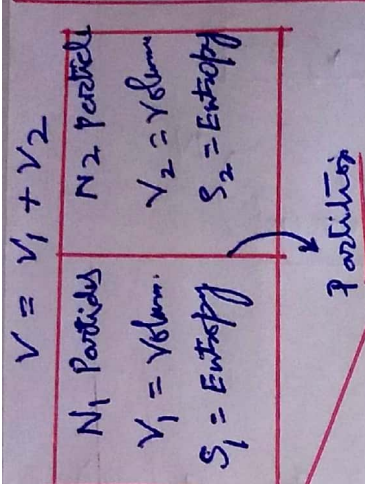
Thus,

$$S = Nk_B \left(\ln \left[\left(\frac{2\pi m k_B T}{h^2} \right)^{\frac{3}{2}} \left(\frac{V e}{N} \right) + \ln \left(w_{e1} + w_{e2} e^{-\beta \Delta \epsilon_{12}} \right) \right] + \frac{3}{2} Nk_B + \left(\frac{Nk_B w_{e2} \beta \Delta \epsilon_{12} e^{-\beta \Delta \epsilon_{12}}}{q_{elec}} \right) \right)$$

Sackur-Tetrode Equation

$$S = Nk_B \left(\ln \left[\left(\frac{2\pi m k_B T}{h^2} \right)^{\frac{3}{2}} \left(\frac{V e}{N} \right) \right] + \frac{3}{2} \right) + Nk_B \left(\ln \left(w_{e1} + w_{e2} e^{-\beta \Delta \epsilon_{12}} \right) + \left(\frac{w_{e2} \beta \Delta \epsilon_{12} e^{-\beta \Delta \epsilon_{12}}}{q_{elec}} \right) \right)$$

$$S = Nk_B \left(\ln \left[\left(\frac{2\pi m k_B T}{h^2} \right)^{\frac{3}{2}} \left(\frac{V e^{5/2}}{N} \right) \right] \right) + S_{elec}$$



Breim-Tasser **
Distinguishability leads to paradox ??

GIBB'S PARADOX ON ENTROPY :-
Removal of Partition causes mixing
Entropy should be doubled being extensive prop.

TOPIC :- Chemical Potential of Monoatomic gases

$$\mu = -k_B T \left(\frac{\partial \ln(Z(N, V, T))}{\partial N} \right)_{V, T}$$

We know $Z(N, V, T) = \frac{(q_{\text{trans}} q_{\text{elec}} q_{\text{nuc}})^N}{N!}$

$$\rightarrow \ln(Z(N, V, T)) = N \ln(q_{\text{trans}} q_{\text{elec}} q_{\text{nuc}}) - (N \ln(N) - N)$$

$$= N \left(\ln(q_{\text{trans}} q_{\text{elec}} q_{\text{nuc}}) + \ln\left(\frac{e}{N}\right) \right)$$

$$\rightarrow \left(\frac{\partial \ln(Z(N, V, T))}{\partial N} \right)_{V, T} = \ln(q_{\text{trans}} q_{\text{elec}} q_{\text{nuc}}) - \left(N \cdot \frac{1}{N} + \ln(N) - 1 \right)$$

Rewriting,
 $q_e = q_{\text{elec}}$
 $q_n = q_{\text{nuc}}$

$$= \ln((q_{\text{trans}} q_{\text{elec}} q_{\text{nuc}}) / N)$$

$$\rightarrow \mu = -k_B T \ln \left[\left(\frac{2\pi m k_B T}{h^2} \right)^{\frac{3}{2}} \left(\frac{V}{N} \right) \right] - k_B T \ln(q_e q_n)$$

Since $V = \frac{N k_B T}{p}$
 For ideal gas

$$\rightarrow \mu = -k_B T \left(\ln \left[\left(\frac{2\pi m k_B T}{h^2} \right)^{\frac{3}{2}} \frac{1}{k_B T} \right] - \ln(q_e q_n) \right) + k_B T \ln(p)$$

$\mu_0(T) + k_B T \ln(p)$

or $\mu = \mu_0(T) + k_B T \ln(p) \rightarrow$ Classical Thermodynamic Eq.