Thermal Physics → Probabilities (due to ignorance)

$N \simeq N_A = 6.022 \cdot 10^{23}$ ✗
$= 1\,\text{mol}$

Global variables

Extensive	Intensive
N, n (# of mols)	P
V	T
E	
	$\mu =$ chemical potential
S Entropy	

given T

given all possible micro states of individual part. i
(e.g.: $\vec{p}$ for a single gas atom)

$$\text{Prob}(E_i) = \underline{C(T)} \cdot \underbrace{g_i(E_i)}_{\#\text{ states w/same energy } E_i} \cdot \underbrace{e^{-E_i/kT}}_{\text{Boltzmann Factor}}$$

kT: thermal energy

$$C = \frac{1}{\sum_i g_i e^{-E_i/kT}}$$

Ex.: e^- in H atom: $E_n = -R_y \frac{1}{n^2}$; $g_n = 2n^2$

$k = 1.38 \cdot 10^{-23}\,\text{J/K} = 8.617 \cdot 10^{-5}\,\text{eV/K}$

$N_i = N_{tot} \cdot \text{Prob}(E_i)$

$$\frac{N_i}{N_j} = \frac{g_i}{g_j} e^{-(E_i - E_j)/kT}$$

g_i: 8, g_j: 2, ΔE_{ij}: e^{-300}

H. atom:
$E_2 - E_1 = R_y\left(\frac{1}{1} - \frac{1}{4}\right)$
$= 10.2\,\text{eV}$
Room $T \simeq 300\,\text{K}$

Continuum: $0 \leq E < \infty$

Ex: $E = T_{kin} = \frac{\vec{p}^2}{2m}$

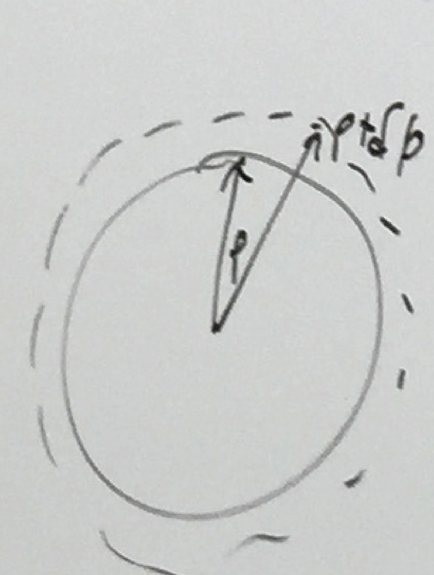
$$d\,\text{Prob}(E \ldots E + dE) = C(T)\, g(E)\, e^{-E/kT}\, dE$$

$$C(T) = \frac{1}{\int_0^\infty g(E)\, e^{-E/kT}\, dE}$$

$g(E)\,dE =$ Phase space Volume between $E \ldots E + dE$

$$g(E)\,dE \propto \Delta V \cdot d^3p \cong \Delta V \cdot 4\pi p^2\, dp$$

$p = \sqrt{2mE}$



$\Rightarrow P \cdot V = n\underbrace{R}_{N_A k} T$ $\qquad E_{tot} = \frac{3}{2} n R T$

$[-P \cdot dV = dE_{tot}]$ $\qquad \#_A \cdot kT$

Fermi

$N_i \leq g_i$

$$N_i = \frac{g_i(E_i)}{e^{E_i/kT} e^{-\mu/kT} + 1}$$

μ

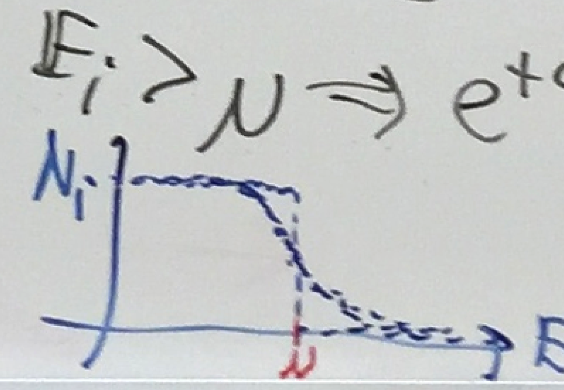
$$= \frac{g_i(E_i)}{e^{(E_i - \mu)/kT} + 1}$$

$\sum N_i = N_{tot} \Rightarrow \mu$

kT small?

$E_i < \mu \Rightarrow e^{-\infty}$

$E_i > \mu \Rightarrow e^{+\infty}$



Bose

$$= \frac{g_i(E_i)}{e^{(E_i - \mu)/kT} - 1}$$