HW sets

I) statistical thermo:
use observable measurements
of c_p, c_v, u, h etc
to gain understanding
of microscale dynamics.

II) Learn: A) equil. statist thermo

B) Quantum Mechanics

C) Macroscopic equil. thermo.

D) Basic Physics

a) ~~...~~ phonon modes in solids

b) Black body photons

c) I ~~Gas~~ models (Quantum) of electron metals

d) I Gas w/ Quantum

Typical stat mechanics

Recipe ⇒ Inverse problem of figuring out microscopic dynamics

1) Guess ~~AA~~ dynamics/ ~~??~~ energetics of microscale system

2) $\boxed{\text{Guess} \Rightarrow \text{system Hamitonian}}$

+ implicit assumption ⇒ energy ~~??~~ is conservative

+ ~~Ham~~ Hamiltonian dyn. models ⇒ "short time scales"

+ problem time ~~scale~~ scales

$\ll \tau_{\text{visous dissp}}$

$\ll \tau_{\text{friction}}$

etc

3) Use Hamiltonian or Schrod. eqn.

a) Equilibrium systems ⟺ systems in which random dynamics are stationary:

⊕ mean properties don't Δ in time

⊕ variances fixed

b) Use stationary S.E.

$$\boxed{E|\psi\rangle = \hat{H}|\psi\rangle} \quad (*)$$

E = eigen energy for our system

$\hat{H}$ = Hamiltonian operator

$|\psi\rangle$ = wave fn (probability density that gives statistical information random quantum system

4

c) (X) $\Longleftrightarrow$ eigenvalue problem

$\Rightarrow E_1, E_2, E_3 \ldots \Rightarrow$ ~~eigen~~ Quantum energy states

$\Rightarrow |\psi_1\rangle, |\psi_2\rangle, |\psi_3\rangle \ldots$ eigen fns = Wave fns

d) $\Rightarrow$ $Q \equiv$ "partition fn"

$$\boxed{Q = \sum_{j=1}^{\infty} e^{-(E_j \beta)}} \; \text{**}$$

E_j = j^{th} Quantum energy level $\boxed{\doteq J}$

$\beta = \frac{1}{K_B T}$ ~~to~~ $\doteq 1/J$

$\boxed{K_B \doteq J/K}$

K_B = Boltzmann's const

e) Given $Q \Rightarrow$ use to calc. theoretical:

$\boxed{U_{system}, H_{system}, C_P, C_V, S}$

f) check e) against experiment $\Rightarrow$ repeat / refine

III) Bridge Relations:

example 1:

Boltzmann's Relation

3* $\boxed{S(E,V,N) = k_B \ln \Omega(E,V,N)}$

some macroscopic observable

equil thermo vbl.

some ~~to~~ math object connected to microscale ~~dy~~ dynamics

(4) In our recipe, we use quantum math

4* to get the microscale math thing

(+) then use Bridge reln $\Rightarrow$ to connect

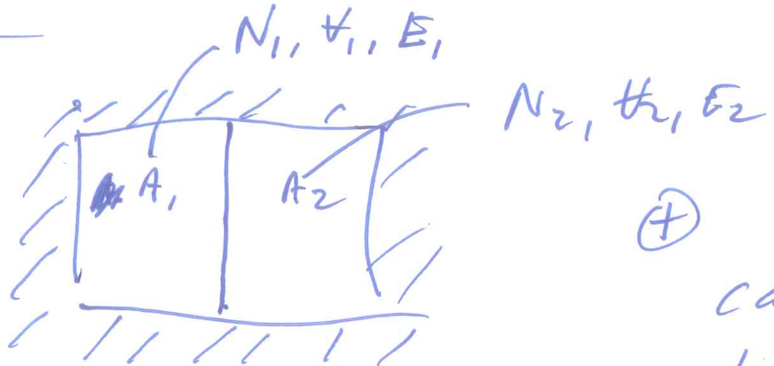
4* to macroscopic thermo

Derive $S = k_B \ln \Omega$

⊕ Ω = no of Q states that are ~~an~~ available to ~~an~~ system of $\boxed{N}$ particles, occupying $\boxed{V}$, ~~and~~ having (nominally) fixed total energy $\boxed{E}$

⊕ $\Omega = \Omega(E, N, V)$

1)



⊕ system 1 can be liquid, gas, plasma.

system 2

2) AFTER BARRIER OUT

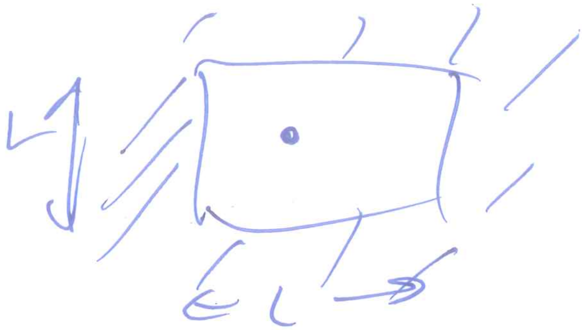
a) $E^0 = E_1 + E_2$

$N^0 = N_1 + N_2$

$\boxed{b) \ \Omega^{(0)} = \Omega^{(1)} \cdot \Omega^{(2)}}$ (5*) 　　　(7)

ASIDE: Meaning of (5*)

consider a single gas ptcl. in insulated box



System = 1 ptcl
N = 1

Model ptcl. = 1 GAS. ptcl
⇒ WALL ptcl interactions weak

(*) $\boxed{\hat{H} = \frac{\hat{p}^2}{2m}}$ (7*)

$\hat{p}$ = "momentum operator"

m = mass ptcl

$\hat{p}^2$

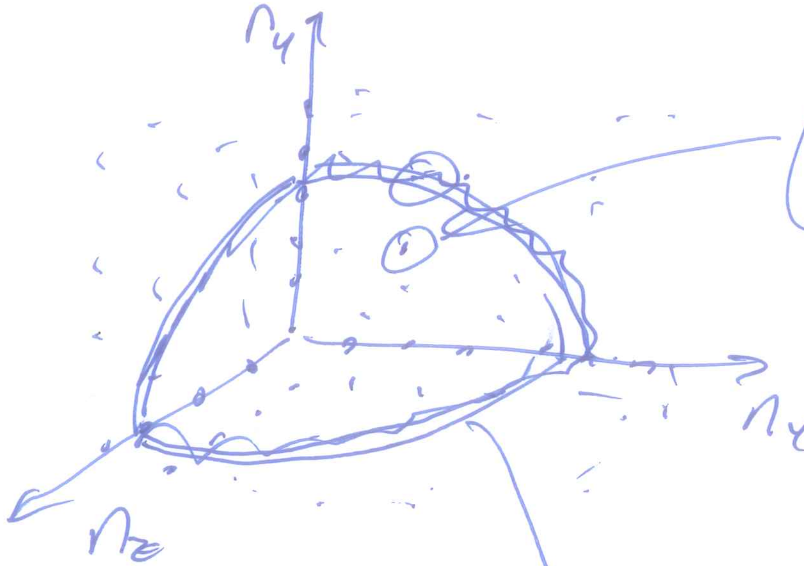
(*) ⇒ (7*) in stationary S.E.

Fixed

n_x, n_y, n_z = pos. integer

(9*) $E(n_x, n_y, n_z) = \frac{h^2}{8mL^2}(n_x^2 + n_y^2 + n_z^2)$

9* GRAPHICAL interpretation:



each point $\Longleftrightarrow$ 1 QUANTUM state for ptcl.

$$(9^*) \to \boxed{n_x^2 + n_y^2 + n_z^2 = \frac{E'}{c}} \quad (10^*)$$

$$(10^*) \Rightarrow \boxed{R^3 = \frac{E'}{c}}$$

$$\Omega(E', V, N=1) \simeq \mathrm{Vol}_{\text{of}}$$