Physics 201 — Day 26

Topics for Exam 3

AC

EM waves

Optics Labs { thin Lens and magnification equations. / Diffraction

Thermal Lab (specific heat of metals)

↳ $Q = cm\Delta T$

* Ideal gas

* Simple Stat Mech (Probability 2-state)

Quiz 4.0

this Fri - Lab X+Z

Next Fri May 4 - Review for Exam 3

Friday May 11th : Exam 3.

AC: $V = X I$ $\quad X_R = R \quad X_L = \omega L$

$V = Z I$ $\quad X_C = \frac{1}{\omega C}$

$$Z = \sqrt{X_R^2 + (X_L - X_C)^2}$$

$$c^2 \frac{d^2E(x,t)}{dx^2} = \frac{d^2E(x,t)}{dt^2}$$

Show $E(x,t) = 5e^{4x-3t}$

"works" and find wave speed, c.

E has units of: $\frac{V}{m}$ x unit meter (m)

t unit seconds (s)

EM Wave 10

Ideal gas law 15

next Mon ~~3~~

next Wed 26

nn Monday 1

nn Wednesday 0

Lab X+2 is probably AC Circuits.

Last time: states of Energy E

$$P_i = \frac{e^{-\beta E_i}}{Z} \qquad \beta = \frac{1}{k_B T}$$

$$Z = \sum_{\text{all } i} e^{-\beta E_i}$$

Example: the atmosphere:

If $T \approx$ constant, find $P(z)$ ← Pressure

$$PV = Nk_BT$$

$$\text{Press} = P = \frac{N}{V} k_B T$$

and $$\frac{N}{V} \propto \text{probability} = \frac{e^{-E\cdot\beta}}{Z}$$

$$P(z) = P_0 e^{-\alpha z}$$

$$\frac{N}{V} \propto e^{-E\cdot\beta} = e^{-mg\overbrace{h}^{z}\cdot\beta}$$

$$\frac{\frac{N}{V}(z)}{\frac{N(0)}{V(0)}} = \frac{e^{-mgz\beta}}{e^{-0}} = e^{-mgz\cdot\beta}$$

$$\frac{N(z)}{V(z)} = \boxed{P(z) = P_0 e^{-mgz\cdot\beta}}$$

What is Entropy?

Randomness, Disorder

$$S = k_B \ln \Omega$$

S: entropy

k_B: Boltzman's Constant $\frac{J}{K}$

Ω: # available microstates

each energy state with energy E_i

can be a "pure" quantum state $\Omega = 1$, $S = 0$

but can have $\Omega > 1$, $S > 0$.

Examples: 1 electron in 1s orbital $\Omega = 2$ (spin up, spin down).

but 2 electrons in 1s orbital $\Omega = 1$ they are "indistinguishable"

2p orbitals (x, y, z) $\uparrow\downarrow$ $\uparrow\downarrow$ $\uparrow\downarrow$

$2e^-$ how many ways can you put in? (meaning: What is Ω?)

200 1
020 1
002 1
$\left.\begin{array}{l}110 \\ 101 \\ 011\end{array}\right\}$ 3, 3, 3 — same: $\uparrow\downarrow 0$, $\downarrow\uparrow 0$, diff: $\uparrow\uparrow 0$, $\downarrow\downarrow 0$

$12 = \Omega$

How does Ω change prob?

P_1 with E_1 Ω_1

$$P_1 \propto \Omega_1 e^{-\beta E_1}$$

of "ways"

Define: $S_1 \doteq k_B \ln \Omega_1$

so solving $\Omega_1 = e^{S_1/k_B}$

$$P_1 \propto e^{S_1/k_B} e^{-\beta E_1} = e^{S_1/k_B - E_1/k_B T}$$

$$= e^{-(E_1 - TS_1)/k_B T} = e^{-\beta \underbrace{(E_1 - TS_1)}_{G}}$$

<u>Gibb's Free Energy</u> $= E - TS + PV$

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2 states (A) and (B)

"solid" (A): set $E_A = 0$, set $S_A = 0$

"liquid" (B): $E_B > 0$, $S_B > 0$

To find T at which they are equally Probable, Set $G_A = G_B$.

$$E_A - T^* S_A = E_B - T^* S_B$$

T^* is temperature at which $P_A = P_B$

$\frac{1}{2}$ "

$$0 = E_B - T^* S_B$$

$$\frac{E_B}{S_B} = T^*$$

(Note: we've picked $E_A, S_A = 0$

so <u>really</u>,

$$\frac{\Delta E}{\Delta S} = T^*$$

→ Non-additive, in general.