

0) Demo that $\Omega \sim O(E)$ or $O(E^f)$ (12) $f \equiv O(10^{24})$

1) $\Phi_i = \Sigma_i(\epsilon) \sim \epsilon^\alpha =$ no of microstates
 available at each energy char. en. ϵ , (where $\epsilon \sim E/N$)

2) $E_n = \hbar \omega (n + \frac{1}{2})$
 $E_n \propto \epsilon^{3/2}$ well section

3) $\Sigma(N, E, V) \sim \Phi_1^f(\epsilon) \sim \epsilon^f \sim \epsilon^{N-M}$

4) $\therefore \Omega \sim \Sigma(f, N, E, V) = \Sigma(f, N, E, V)$

* Rough notes

$\sim \frac{\partial \Sigma}{\partial E} \Delta E$
 $\sim \frac{\partial(\Phi_1^f)}{\partial \Phi_1} \frac{\partial(E/f)}{\partial E} \Delta E$
 $\sim f \Phi_1^{f-1} \left(\frac{1}{f}\right) \Delta E \quad (f \Phi_1, M)$

5) $\left| \begin{array}{l} \text{if } \Delta E/E \sim 10^{-5} \\ \Rightarrow \Delta E \sim 10^{-5} E \\ \oplus \text{ if } E/k \sim 10^{-23} \text{ J} \\ \Rightarrow \Delta E \sim f E M_0 \\ \sim f \Phi_1 M_0 \end{array} \right.$

6) $\ln \Omega \sim (f-1) \ln \Phi_1 + \ln f + \ln \Delta E + \ln M_0$
 small $\ln \Phi_1 \ll f \ln \Phi_1$
 7) $\boxed{\ln \Omega \sim f \ln \Phi_1}$

8) or $\ln \Omega \sim f(\ln E - \ln f)$ NOT SURE NOW

But argues $\boxed{\Omega \sim E^f}$ roughly true

9) formula
 $\boxed{\Omega \Rightarrow \Gamma \sim (E/N)^N \sim (E/f)^f}$

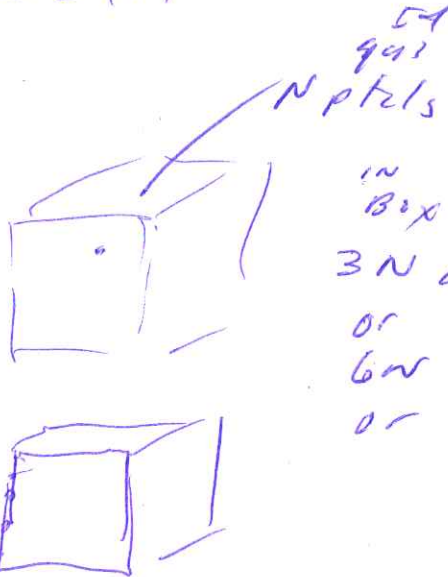
①

Recall arg that

$$\Omega(N, V, T) \sim \Omega(E)$$

if $f = \text{d.o.f.}$

ex 1



in box $\sim$
3N d.o.f

or
b/c if we include rot'n
or



etc

1) $\Phi_k(E) \propto E^\alpha$

$$\alpha = f/2$$

for ^{1} harm oscill $\Rightarrow E_n = \hbar \omega \left(\frac{n}{2} + \frac{1}{2} \right)$
for ^{d} Idgas mole $\Rightarrow E_n = \left(\frac{n^2}{8mL^2} \right) \hbar^2$

$$\Rightarrow \Omega_x \sim E_n^{1/2}$$

$$a = 1/2$$

2) for f d.o.f $\Rightarrow$ N ptcls each w/

$$\Sigma \sim \Phi_k(E) \quad x = f/N \text{ d.o.f.}$$

now = no of energy states

3) $E \sim E/f$ in 545 N ptcls having
Total energy $\leq E$

$$\therefore \Omega(E, V, N) \sim$$

4) $\Rightarrow \Omega \Rightarrow$ we've been looking

2) No Ω = No of energy states within $\pm \Delta E$ of E ; ΔE = precision of measurement

$$5) \Omega \sim \Sigma(E + \Delta E, N, V) - \Sigma(E, N, V)$$

$$\sim \frac{\partial \Sigma}{\partial E} \bigg|_{N, V} \Delta E$$

$$\sim \frac{\partial (\Phi^F)}{\partial E} \Delta E$$

$$\sim \frac{\partial (\Phi_1^F)}{\partial \Phi_1} \left(\frac{\partial \Phi_1}{\partial E} \right) \Delta E$$

$$\sim \Phi_1^{F-1} \frac{1}{E} \Delta E$$

$$\Phi_1 = C_0 E^{\alpha}$$

$\alpha(1)$
↓
 $\frac{1}{E^{\alpha}}$

$$E = \frac{3}{2} NKT$$

$10^{23} (6) 10$

6) ASS.
 $\Delta E \propto ME$

$$M = 0(10^{-4}) 10^{-3} (10^{-5})$$

$$7) \Rightarrow \Omega \sim \Phi_1^{F-1} ME$$

$$8) \Rightarrow \ln \Omega \sim f \ln \Phi_1 + \ln M + \ln E$$

$$9) E = \frac{3}{2} KT$$

$$\sim \frac{3}{2} (1.6) \cdot 10^3 (10^{-23}) 5 (300)$$

$$E \sim 10^{-20} J$$

⇒

3

$$P = n \bar{p} T = \frac{N \bar{p} T}{A_0} = N k T = (6 \times 10^{23}) 1.6 (10^{-23})$$

$$10^3 (P) (10^{-6} m^3) = 1 \left(\frac{8.314}{mol} \right) J (300)$$

$$= 3000 J$$

$$V = (10 cm)^3$$

$$N = 6 (10^{23})$$

$$P = 3 (10^6) J / m^3$$

$$= 3 (10^6) N m / m^3$$

$$= 3 (10^6) N / m^2$$

$$= \underline{\underline{30 atm}}$$

from path 1.4.6

$$\frac{8 \pi V^{2/3} \epsilon E / N}{h^2} = C^*$$

choose Air: $M \approx \frac{30 kg}{kg/mol} \frac{1 kg/mol}{6 (10^{26}) (kg/mol)^{-1}}$

$$M \approx 5 (10^{-26} kg)$$

$$V = 10^{-3} m^3$$

$$h = 6.6 (10^{-34}) m^2 kg / s$$

$$E = 3 (10^3) N-m$$

$$N = 1 mol = 6 (10^{23})$$

→ ~~OK~~

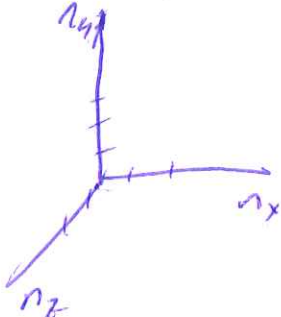
$$\rightarrow C^* = \frac{8 \cdot 5 (10^{-26}) kg (10/3)^{2/3} m^2 \cdot 3000 N-m}{6 (10^{23}) (6.6)^2 (10^{-34})^2 m^2 kg^2 / s^2}$$

$$\boxed{C^* = \frac{1.2 (10^4) 10^{-25}}{(2.4) (10^2) 10^{-45}} \sim \underline{\underline{0.5 (10^{20})}}}$$

1) Derive $\Sigma(\epsilon, N, V)$ (16)
 $n_x^2 + n_y^2 + n_z^2 \leq \frac{8mL^2 E}{h^2}$ pattern of states in 3D box

2) For given energy E , there are $n_x^2 + n_y^2 + n_z^2$ possible energy states for single pt in box

3) Q: what's $\Sigma(1, E_{max}, V)$?

4)  : how many solns
 $(= (n_x, n_y, n_z)'s) \text{ satisfying } \sum_{i=1}^{3N} n_i^2 \leq \frac{8mLE_{max}}{h^2}$
 = how many quantum states?

$\Sigma =$ NO OF triples (n_x, n_y, n_z) in pos. quad

Q: At 17 files

D.M	2	3	4	Q
2-D	~ 4	~ 9	~ 16	$\sim Q^2$
3-D	~ 8	~ 27	~ 64	$\sim Q^3$
M-D	2^M	3^M	4^M	$\sim Q^M$
$M=3N$	2^{3N}	3^{3N}	4^{3N}	$\sim Q^{3N}$

(18)

$$\therefore 5) \quad \boxed{\Sigma \epsilon \approx Q^{3N}}$$

6) in two cases where

for all $n_i = 0$ except n_I $I=1,2,3 \dots 3N$

ties

physics

$$R = Q = n_{I \max} = \text{max possible running no for}$$

or $n_{I \max} = Q = \sqrt{\frac{8mL^2 E_{\max}}{h^2}}$ from starting en scale dist.

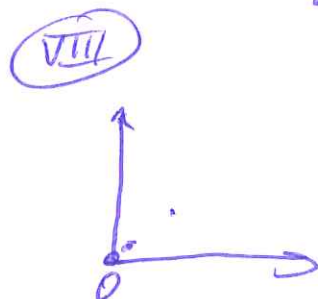
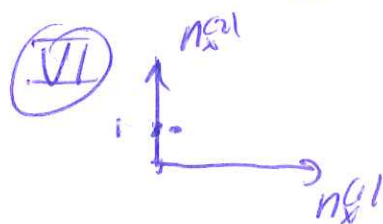
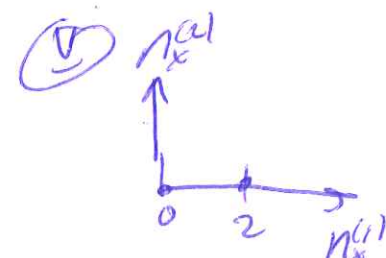
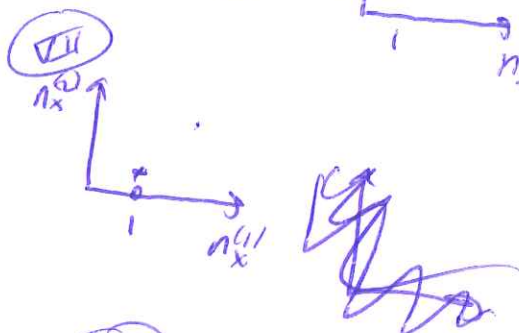
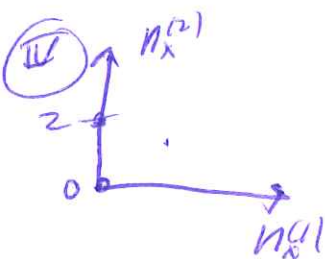
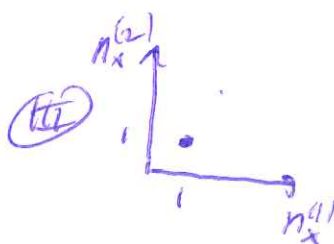
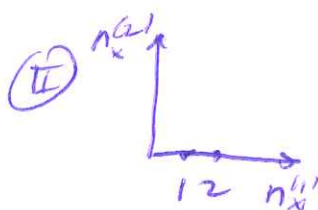
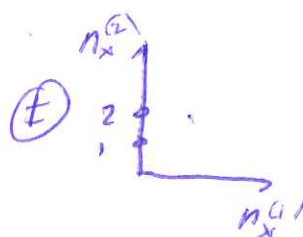
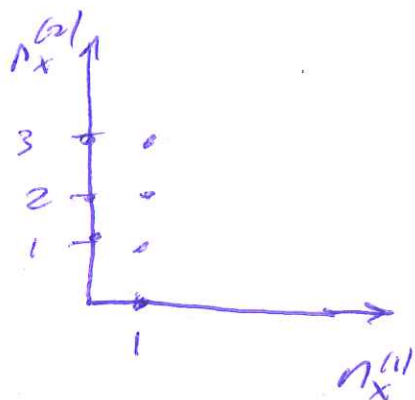
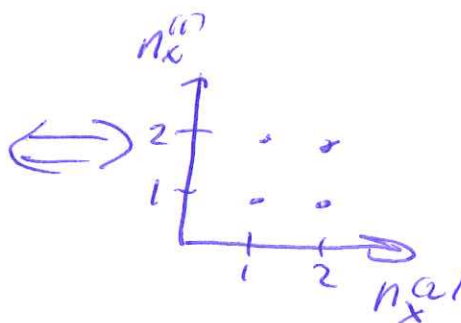
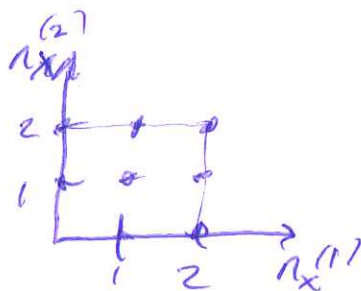
7) i.e. $Q^{3N} = \Sigma (n_i, \epsilon_{i \max})$

or 7a) $\boxed{\Sigma \approx \left(\frac{8mL^2 E}{h^2} \right)^{3N/2}}$

or 7b) $\boxed{\Sigma (n_i, \epsilon_{i \max}) \approx \left(\frac{8mL^2 E}{h^2} \right)^{3N/2}}$

$$\Omega \approx \frac{V^N}{h^{3N}} \left(\frac{8mE}{h^2} \right)^{3N/2}$$

(1d)



2
Distinguishable
ptcls/
Total energy
= 2

~~Ω = 8~~
Ω = 8 (I think)
Disting

For Indistinguishable
ptcls
① & ②, ④ & ⑤, ⑥ & ⑦
equivalent →
count only
one of each
pair!

Ω_{quantum} = 5

$$\Rightarrow \Omega_{\text{QUANTUM}} \sim \frac{\Omega_{\text{Disting}}}{2!} \sim \frac{\Omega_{\text{Disting}}}{N!}$$

I) 0) if $\vec{p} \approx 10^5 \text{ eV/c}$

1) $\vec{p} \rightarrow -i\hbar \vec{\nabla}$

$\vec{H}$ operator

$$H = \frac{1}{2}mv^2 + V(x)$$

$$H = \frac{p^2}{2m} + V$$

2)

$$\left(\frac{\hbar^2 \nabla^2}{2m} + V \right) \psi = E \psi$$

eigenvalue

on

2)

for p.m. in box

$$\sqrt{n_x^2 + n_y^2 + n_z^2} = \frac{8\pi^{2/3} M E_{\text{max}}}{\hbar^2}$$

if we can

show

$$\Sigma_i (N=1, V, E_{\text{max}})$$

a)

given

$$n_x^2 +$$

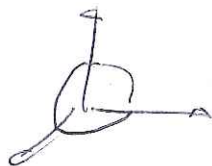
$$= R^2 = E_{\text{max}}^*$$

$$\Rightarrow R = \sqrt{E_{\text{max}}^*}$$

b)

intensity of (x)

$\Rightarrow$



$\Rightarrow$

$$n_x, n_y, n_z$$

Q's of states

$$2 \times 2 \times 2$$

$$2 \times 2 \times 2 \sim 2^3$$

$$3 \times 3 \times 3 \sim 3^3$$

$$Q \sim Q^3$$

vers 2

...

for

$$E_{\text{max}}^*$$

with

$$R = \sqrt{E_{\text{max}}^*}$$

there are

Q^3 states

$$Q = R$$

$$\Rightarrow \Sigma_i = Q^3 = R^3 = E_{\text{max}}^{3/2}$$

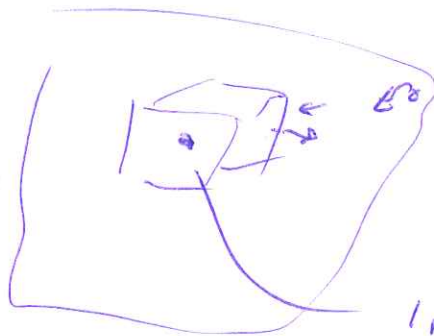
$$1) n_x^2 + n_y^2 + n_z^2 = \frac{8mE_1 L^2}{h^2} \equiv E_{1, \max}^* \quad (a1)$$

2) Geometric interpretation of 1) is in n_x, n_y, n_z space

$$R^2 = E_{1, \max}^*$$

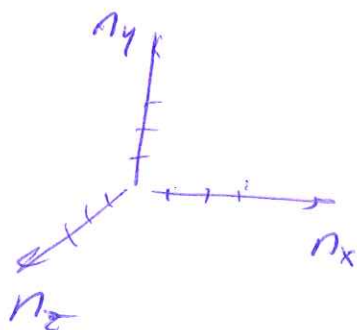
3) Q: how many states = points are there $\leq E_{1, \max}^*$? n_x, n_y, n_z

4) physics



1 ptcl in box
exchanging
B w/ bucket
 $B_0 = B_1 + B_2$

5) Ans from
Geom. interp.,



$$R=1 \quad \begin{matrix} \text{Total} \\ \text{Q states} \end{matrix} 1^3$$

$$R=2 \quad 2^3$$

$$R=3 \quad 3^3$$

$$R=4 \quad 4^3$$

$$R=Q \quad Q^3$$

6) $\therefore R = Q^3 \Rightarrow R = E_{1, \max}^*$

Since $R^2 = E_{1, \max}^* \Rightarrow R = E_{1, \max}^*$

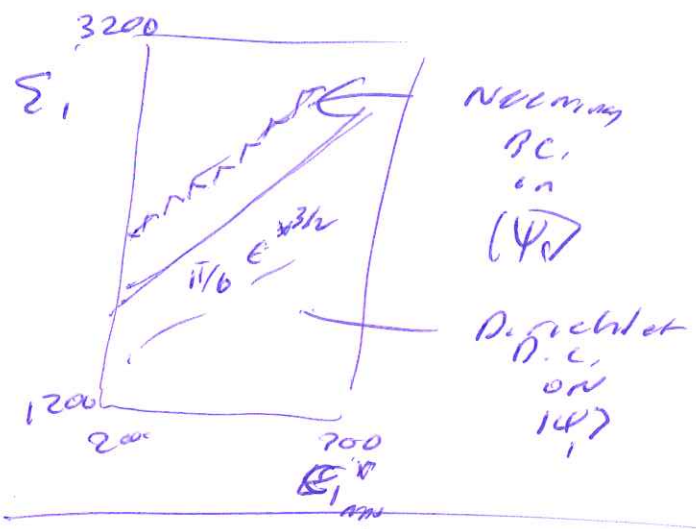
$$Q^3 = R^3 = (E_{1, \max}^*)^{3/2}$$

(b)

2) Book

$Q^3 \equiv \Sigma_1 = \left(\frac{8mL^2 E_1}{h^2} \right)^{3/2} =$ NO OF QUANTUM STATES FOR L ptcl in a box having max energy E_1

$(Q^3 \approx R^3 = E^{3/2})$ THIS IS plotted on Pathway



8) Better est. : AS $E \rightarrow \infty$

8) $\frac{1}{8}$ sphere = $\frac{4\pi R^3}{3(8)}$ $Q^3 \rightarrow \frac{1}{8} \left(\frac{4\pi R^3}{3} \right)$

$$\Sigma_1 = \frac{\pi}{6} E_{max}^{3/2}$$

better

II)

FOR N FERMION ptcls IN BOX

$\Sigma_N = \Sigma(N, V, E_{tot}) \equiv$ TOT NO OF STATES AVAILABLE TO N QUANT. & GAS ptcls

$$\begin{aligned} \Sigma_N &= \Sigma_1^N = \left(\frac{\pi}{6} E_{max}^{3/2} \right)^N \\ &\approx \left[\frac{\pi}{6} \left(\frac{8mL^2}{h^2} E \right)^{3/2} \right]^N \end{aligned}$$