Celsius or Kelvin?

$0°C \rightarrow 273\,K$

difference in temp

$100°C \rightarrow 373\,K$

Boiling - Freezing: $100°C$, $100\,K$

$$Q = m\,C_v\,\Delta T$$

$$S = \int_{T_i}^{T_f} \frac{dQ}{T} = \frac{m\,C_v}{T}\,dT = m\,C_v \ln\left(\frac{T_f}{T_i}\right)$$

$$\frac{T_f}{T_i} = \frac{100\cancel{°C}}{0\cancel{°C}} \rightarrow \left(\frac{373\cancel{K}}{273\cancel{K}}\right)$$

Water $C_v = \dfrac{1\,cal}{gram\,°C} = \dfrac{1\,cal}{gram\,°K}$ 4.18 J

3 states H, T, S — 4 coins

$\cancel{4}^3$ $3^4 = 81$ microstates

macrostates = 15 — $\frac{N(N+1)}{2}$

HHHH (1)

TTTT (1)

SSSS (1)

HTTT, THTT, TTHT, TTTH (4)

THHH - - - - - (4)

HHTT, HTTH, TTHH

HTHT, THTH, THHT (6)

$\binom{4}{2} = \frac{4!}{2!2!}$

HS (4) (4) (6)

TS (4) (4) (6)

HHTS — $\frac{4!}{2!1!1!} = 12$

TTHS — 12

SSTH — 12

Bowling Ball

$f = ?$

$f = 5$

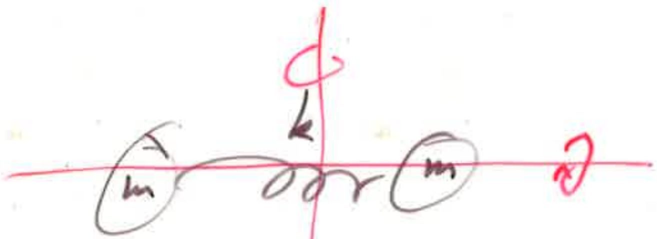
Trans in x $\quad \frac{1}{2} m v_x^2$

Trans in y $\quad \frac{1}{2} m v_y^2$

rotations $\quad \frac{1}{2} I_x \omega_x^2$

$\frac{1}{2} I_y \omega_y^2$

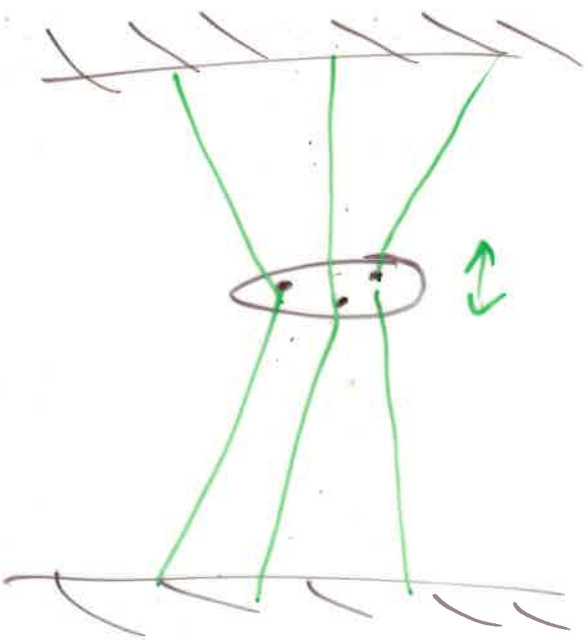
$\frac{1}{2} I_z \omega_z^2$



$N \sim U^f$

$KE = \frac{1}{2} \mu v_r^2$

$PE = \frac{1}{2} k \ell^2$ $\qquad f = 2$



Vertical vibrations

$\frac{1}{2} m v_z^2, \ \frac{1}{2} k z^2$ $\qquad 2$

x vibration $\qquad 2$

y vibrations $\qquad 2$

twisting vibrations

$\frac{1}{2} I_z \omega^2 + \frac{1}{2} N \theta^2$ $\qquad 2$

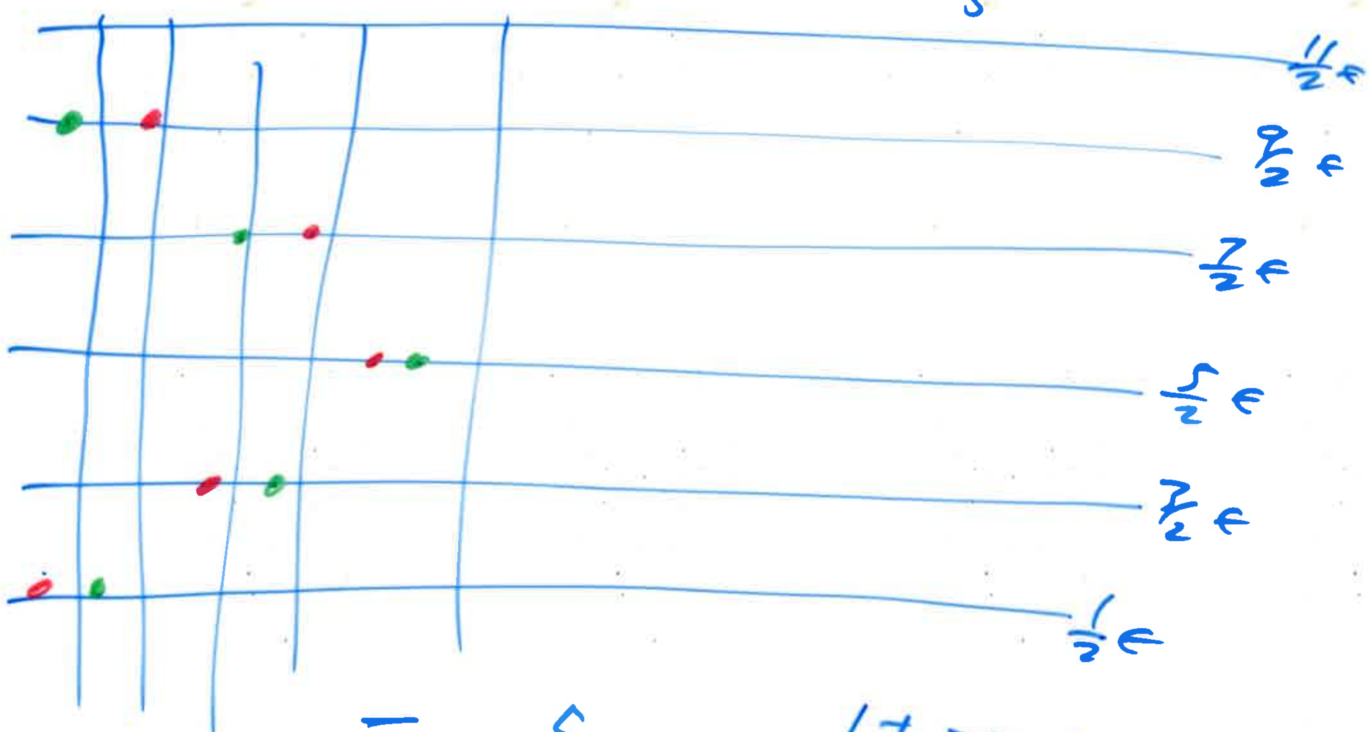
2 particles mass m, distinguishable

in a SHO potential

$$U = \frac{1}{2} m\omega^2 x^2$$

Total energy = 5ϵ, how many microstates

5



$\bar{E} = \frac{5}{2}\epsilon$ $\quad kT \gg \epsilon$

for green particle $r = \dfrac{P(\frac{3}{2}\epsilon)}{P(\frac{1}{2}\epsilon)} = \dfrac{e^{-\beta(\frac{3}{2}\epsilon)}}{e^{-\beta(\frac{1}{2}\epsilon)}} < 1$

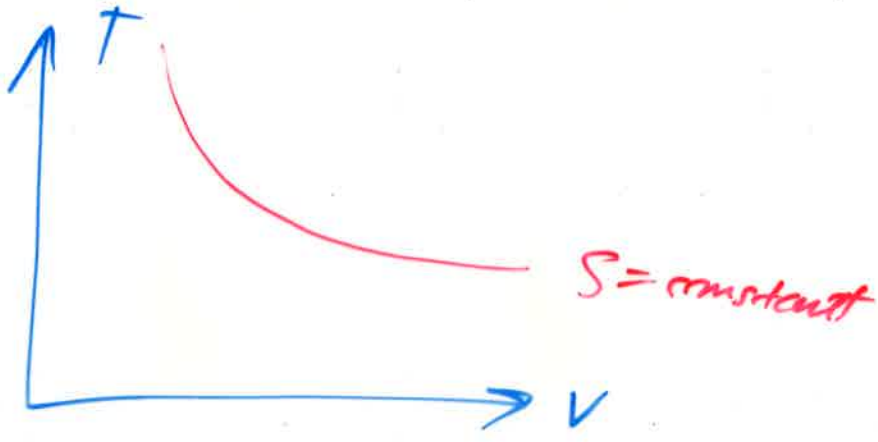
$\beta = \dfrac{1}{k_B T}$

low T : $r \sim 0$

high T : $r \sim 1 < 1$

N fixed

$$-\left(\frac{\partial U}{\partial V}\right)_{SN} = -\left[\left(\frac{\partial U}{\partial V}\right)_{TN} - \left(\frac{\partial U}{\partial S}\right)_{VN}\left(\frac{\partial S}{\partial V}\right)_{TN}\right]$$



$$\Delta U = \left.\frac{\partial U}{\partial V}\right)_T \Delta V + \left.\frac{\partial U}{\partial T}\right)_V \Delta T$$

at fixed S

$$\overset{0}{\cancel{\Delta S}} = \underbrace{\left.\frac{\partial S}{\partial V}\right)_T \Delta V + \left.\frac{\partial S}{\partial T}\right)_V \Delta T}$$

$$\left.\frac{\Delta T}{\Delta V}\right)_S = -\frac{\left.\frac{\partial S}{\partial V}\right)_T}{\left.\frac{\partial S}{\partial T}\right)_V}$$

$$\frac{\Delta U}{\Delta V} = \left.\frac{\partial U}{\partial V}\right)_T + \frac{\partial U}{\partial T}\frac{\Delta T}{\Delta V} = \left(\frac{-\frac{\partial S}{\partial V}}{\frac{\partial S}{\partial T}}\right)$$

$$\frac{\partial U}{\partial S}\frac{\partial S}{\partial T}$$

$$\left.\frac{\partial U}{\partial V}\right)_{SN} = \left.\frac{\partial U}{\partial V}\right)_{TN} - \left.\frac{\partial U}{\partial S}\right)_{VN}\left.\frac{\partial S}{\partial V}\right)_{TN}$$