1.

EINSTEIN SOLID

SOLID COMPOSED OF OSCILLATORS

- N OSCILLATORS = $N/3$ ATOMS
- DEGREES OF FREEDOM/ATOM 6
- EQUIPARTITON THEOREM $U = N/3 \cdot 6 \cdot \frac{1}{2} kT$

$$= \underline{NkT}$$

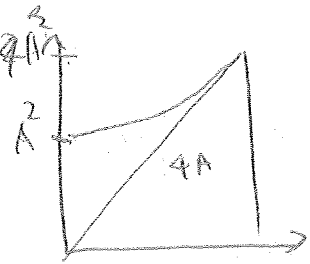
NOTE N OSCILLATORS $N/3$ ATOMS

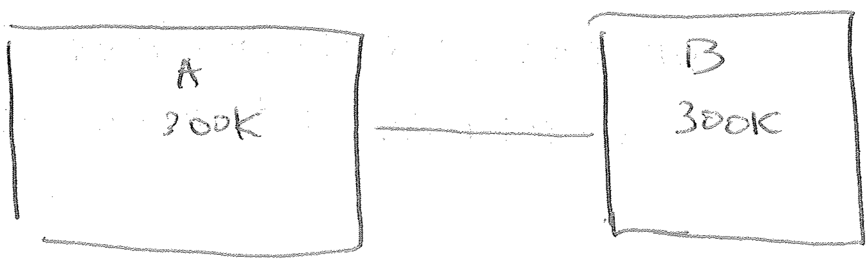
SO NOW WE KNOW HOW TO DEAL W/

EINSTEIN SOLID, IDEAL GAS, 2 STATE MAGNET

So $ds = \frac{Q}{T}$

LET'S CONSIDER





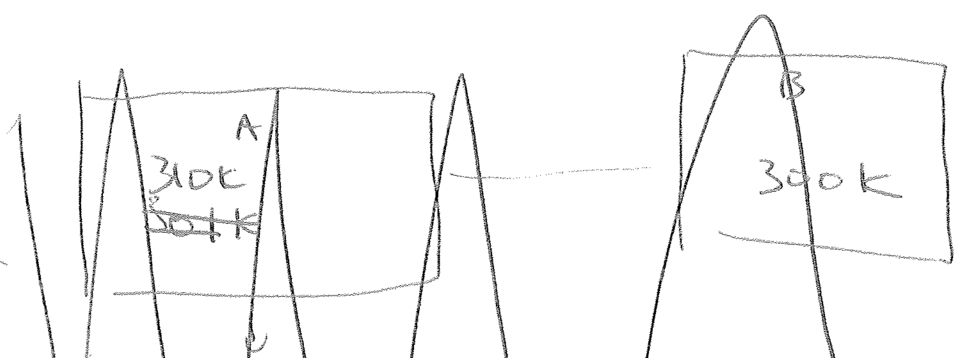
$\frac{(A+B)^2}{4AB}$

~~$C_v = 400$ J/K~~

$Q = 0$ $ds = 0$

A B

$\frac{A+B}{2}$



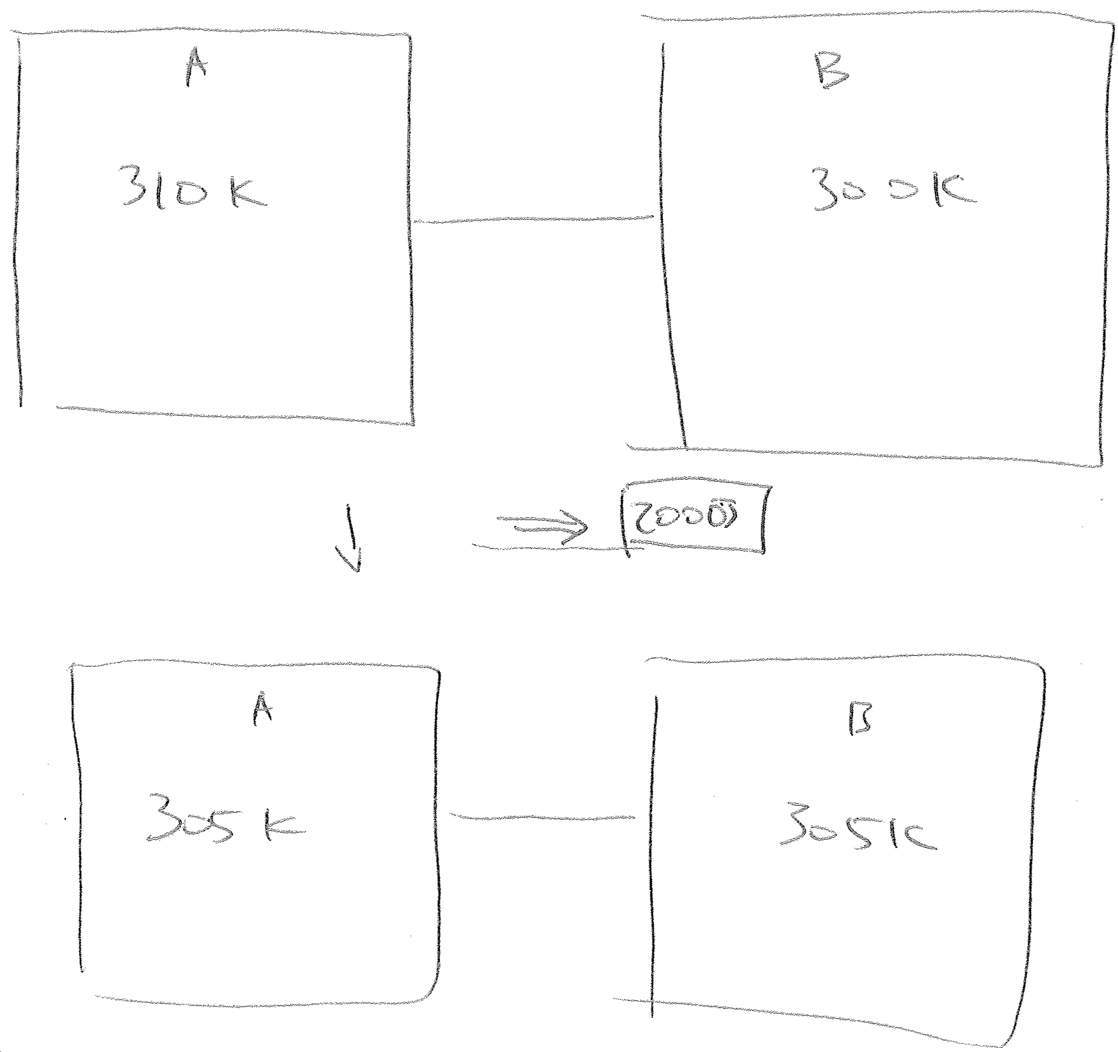
$\frac{A^2+2AB+B^2}{4AB}$

305K 305K

(A^2+B^2) $(2AB)$

$\Delta S_A = 400 \text{ J/K} \ln \frac{305}{310} = -6.5 \text{ J/K}$

$\Delta S_B = 400 \text{ J/K} \ln \frac{305}{300} =$



$\Delta S_A = 400\ J/K \ln \frac{305}{310} = -6.5\ J/K$ $\quad Q = -2000\ J$

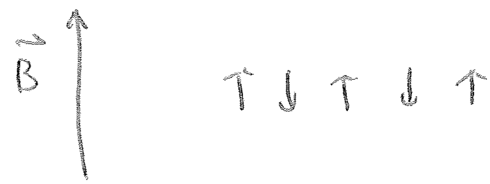
$\Delta S_B = 400\ J/K \ln \frac{305}{300} = 6.61\ J/K$ $\quad Q = +2000\ J$

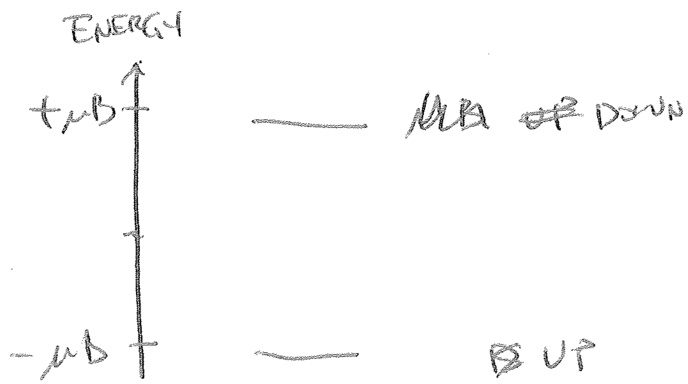
ΔS_{TOTAL} $= +0.11\ J/K$

SORT OF LIKE

ENTROPY FORCES DIRECTION OF FLOW

TWO STATE PARAMAGNET





$$U_{TOTAL} = \mu B \left(N_{\downarrow} - N_{\uparrow} \right)$$

$$= \mu B \left(N - 2N_{\uparrow} \right)$$

$$M = \mu \left(N_{\uparrow} - N_{\downarrow} \right) = -\frac{U}{B}$$

$$\Omega = \binom{N}{N_{\uparrow}} = \frac{N!}{N_{\uparrow}!\, N_{\downarrow}!}$$

SOME PECULIARITY OF TWO STATE MAGNET

AT $T \to 0$

$B \uparrow \quad \uparrow \uparrow \uparrow \uparrow \uparrow \uparrow \uparrow \uparrow \ldots$

i.e. $\Omega = 1 \quad S = 0$

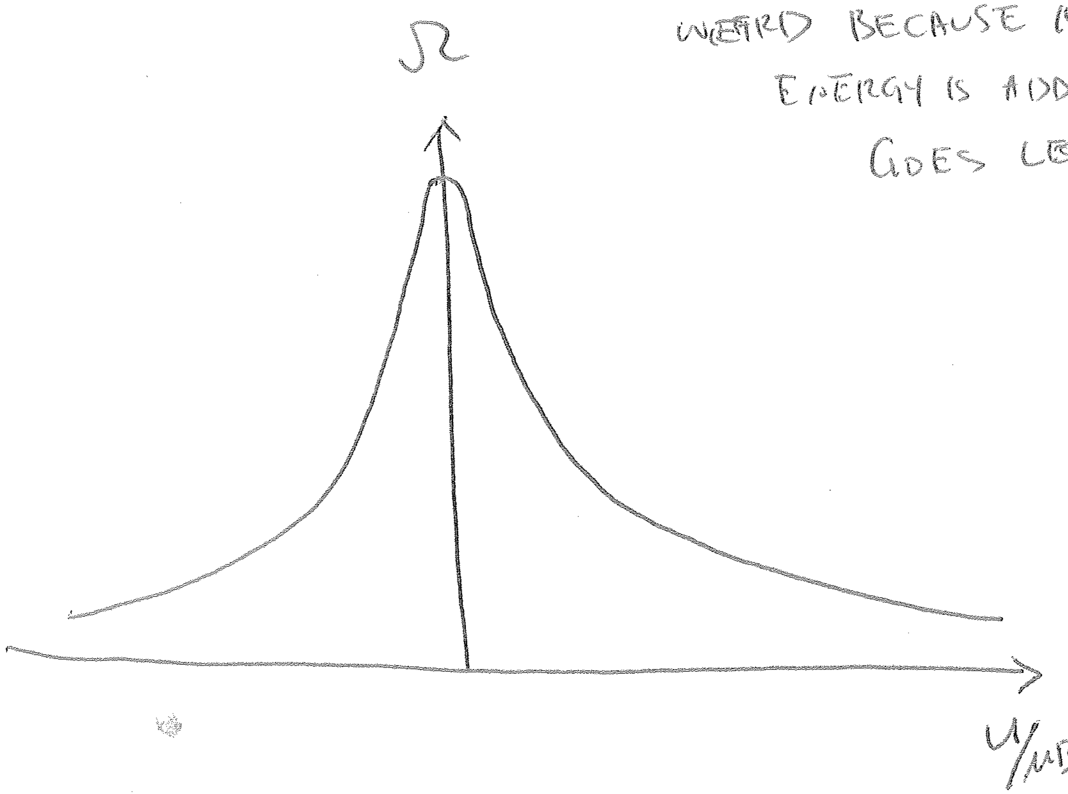
2\. AT $T \to \infty$

$\uparrow \quad \uparrow \downarrow \uparrow \downarrow \uparrow \uparrow \uparrow \downarrow \uparrow \downarrow$

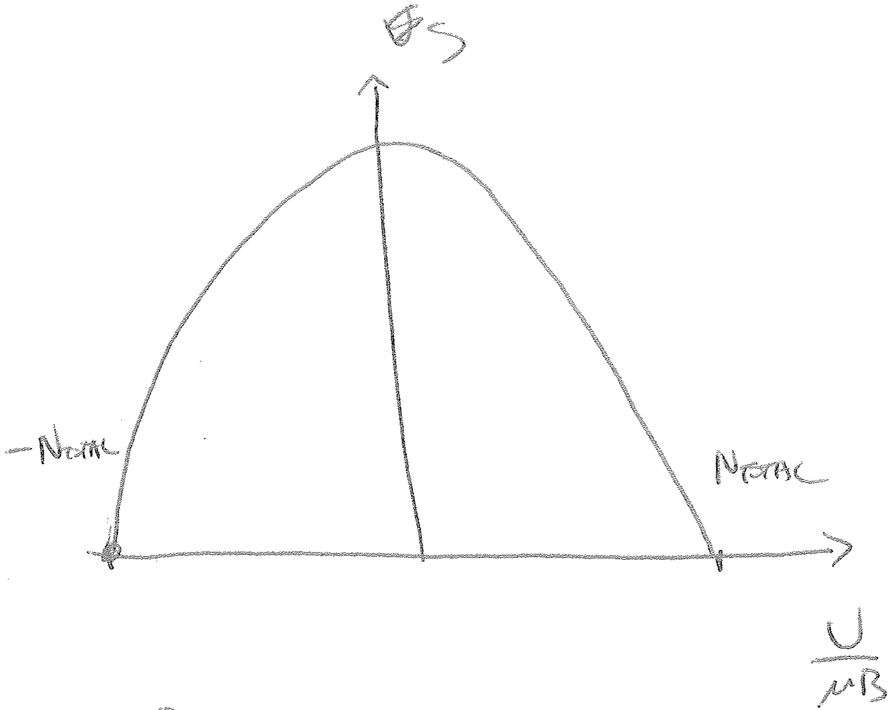
$N_\uparrow = N_\downarrow$

Ω MAXMIZED

1\.



WEIRD BECAUSE MORE ENERGY IS ADDED IT GOES LESS



$\frac{\partial S}{\partial U} \Rightarrow$ POSITIVE

$dS = \frac{Q}{T}$ POSITIVE ABSORBS ENERGY

$dS < 0$ GETS RID OF HEAT
SO GO BACK TO 2.

ANALYTIC SOLUTION

$$S/k = \ln \frac{N!}{N_\uparrow!\, N_\downarrow!} = \ln N! - \ln N_\uparrow! - \ln(N - N_\uparrow)!$$

STIRLING APPROXIMATION

$$S/k = N \ln N - N_\uparrow \ln N_\uparrow - (N - N_\uparrow) \ln (N - N_\uparrow)$$

$$U = \mu B (N - 2N_\uparrow) \qquad N_\uparrow = \frac{1}{2}\left[N - \frac{U}{\mu B}\right]$$

$$\frac{1}{T} = \left(\frac{\partial S}{\partial U}\right)_{N,B} = \frac{\partial N_\uparrow}{\partial U}\frac{\partial S}{\partial N_\uparrow} = -\frac{1}{2\mu B}\frac{\partial S}{\partial N_\uparrow}$$

$$\frac{1}{k}\frac{\partial S}{\partial N_\uparrow} = \left[-\ln N_\uparrow \cancel{-1} + \ln(N - N_\uparrow) \cancel{+1}\right]$$

$$= k \ln \frac{(N - N_\uparrow)}{N_\uparrow}$$

$N_\uparrow$

$$\frac{1}{T} = \frac{1}{2\mu B} \ln\left(\frac{N - \frac{U}{\mu B}}{N + \frac{U}{\mu B}}\right)$$

$$U = N\mu B\left(\frac{1 - e^{2\mu B/kT}}{1 + e^{2\mu B/kT}}\right) = -N\mu B \tanh\left(\frac{\mu B}{kT}\right)$$

$$M = N\mu \tanh\left(\frac{\mu B}{kT}\right)$$