$S = k \ln N$

given V & N: $\left(\frac{\partial S}{\partial E}\right)_1 = \left(\frac{\partial S}{\partial E}\right)_2$ <=> heat balance

$$T = \frac{\partial E}{\partial S}$$

minus - temperature :

For ↑↑↑↓↑↑↓↓↓↓↑↓ system:

- The lowest possible energy $= -N\mu B$ $T=0$ condition: ↑↑↑↑↑↑↑↑↑↑↑↑

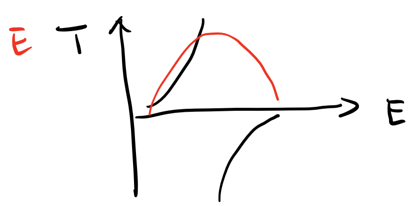
  Condition number : 1 $S = k \ln 1 = 0$

- inject energy $= 2\mu B$ to rise the temperature, then there's an atom's spin overturn in N possible ways. $S = k \ln N$

- $4\mu B$ $\frac{N(N-1)}{2}$ $S = k \ln \frac{N(N-1)}{2}$ two

- $E=0$ half ↑ half ↓ S_{max}

- E↑ $E_{max} = N\mu B$ $S=0$



In real world:

1. coupling is weak enough between atom spins and other degrees of freedom.
2. Coupling between different atoms' spins
3. energy flow from spins to other degrees of freedom is much longer than energy flow between different spins.