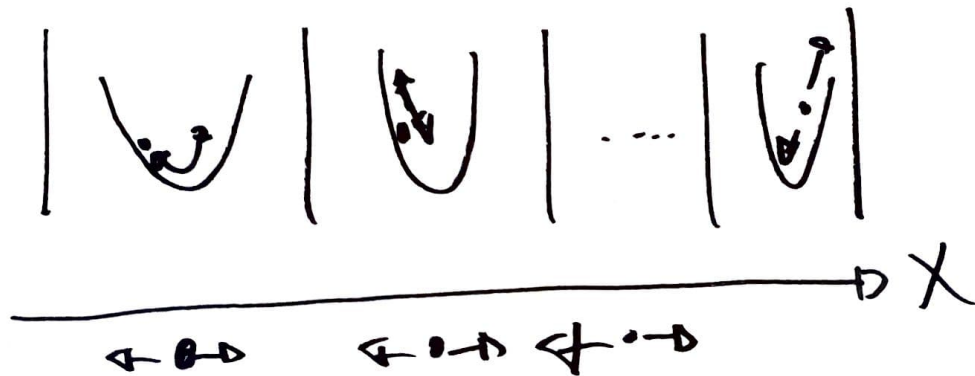


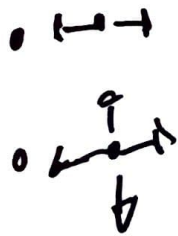
3. Sólido de Einstein

$$\bar{E}_i = \frac{1}{2} \hbar \omega + n_i \hbar \omega$$

$$E = \sum_{i=1}^N E_i, \quad \hbar = \frac{h}{2\pi} - \text{const. Planck}$$



$$\frac{N!}{N_1! N_2!}$$



$$\Omega(E, N) = \frac{\left(\frac{E}{\hbar \omega} + \frac{N}{2} - 1 \right)!}{\left(\frac{E}{\hbar \omega} - \frac{N}{2} \right)! (N-1)!}$$

$$S = k_B \ln \Omega, \quad \gamma = \frac{S}{N}$$

$$\gamma(u) = \lim_{N \rightarrow \infty} \frac{k_B}{N} \ln \Omega$$

$\frac{E}{N} = u$

(1)

$$\ln N! \cong N \ln N - N$$

(5)

$$\ln \Omega = \ln \left[\left(\frac{E + N}{h\nu} - 1 \right)! \right] - \ln \left[\left(\frac{E}{h\nu} - \frac{N}{2} \right)! \right] - \ln \left[(N-1)! \right]$$

$$= \left(\frac{E + N}{h\nu} - 1 \right) \ln \left(\frac{E + N}{h\nu} - 1 \right) - \left(\frac{E}{h\nu} - \frac{N}{2} \right)$$

$$- \left\{ \left(\frac{E}{h\nu} - \frac{N}{2} \right) \ln \left(\frac{E}{h\nu} - \frac{N}{2} \right) - \left(\frac{E}{h\nu} - \frac{N}{2} \right) + (N-1) \ln (N-1) - (N-1) \right\}$$

(6)

$$\frac{\ln \Omega}{N} = \left(\frac{u}{\hbar \omega} + \frac{1}{2} - \frac{1}{N} \right) \ln \left[N \left(\frac{u}{\hbar \omega} + \frac{1}{2} - \frac{1}{N} \right) \right] - \left(\frac{u}{\hbar \omega} + \frac{1}{2} - \frac{1}{N} \right)$$

$$- \left\{ \left(\frac{u}{\hbar \omega} - \frac{1}{2} \right) \ln \left[N \left(\frac{u}{\hbar \omega} - \frac{1}{2} \right) \right] - \left(\frac{u}{\hbar \omega} - \frac{1}{2} \right) \right.$$

$$\left. + \left(1 - \frac{1}{N} \right) \ln \left[N \left(1 - \frac{1}{N} \right) \right] - \left(1 - \frac{1}{N} \right) \right\}$$

(7)

$$\frac{\ln \Omega}{N} = \left(\frac{u}{\hbar \omega} + \frac{1}{2} \right) \left[\ln N + \ln \left(\frac{u}{\hbar \omega} + \frac{1}{2} \right) \right] - \left(\frac{u}{\hbar \omega} + \frac{1}{2} \right)$$

$$- \left\{ \left(\frac{u}{\hbar \omega} - \frac{1}{2} \right) \left[\ln N + \ln \left(\frac{u}{\hbar \omega} - \frac{1}{2} \right) \right] - \left(\frac{u}{\hbar \omega} - \frac{1}{2} \right) \right.$$

$$\left. + \ln N + \ln \left(\frac{u}{\hbar \omega} - \frac{1}{2} \right) - 1 \right\}$$

(8)

$$\frac{\ln \Omega}{N} = \frac{u}{\hbar \omega} \ln N + \frac{\ln N}{2} + \left(\frac{u+1}{\hbar \omega} + \frac{1}{2} \right) \ln \left(\frac{u}{\hbar \omega} + \frac{1}{2} \right) - \left(\frac{u}{\hbar \omega} + \frac{1}{2} \right)$$

$$- \frac{u}{\hbar \omega} \ln N + \frac{\ln N}{2} - \left(\frac{u}{\hbar \omega} - \frac{1}{2} \right) \ln \left(\frac{u}{\hbar \omega} - \frac{1}{2} \right) + \frac{u}{\hbar \omega} - \frac{1}{2}$$

$$- \ln N + 1$$

$$\frac{\ln \Omega}{N} = \left(\frac{u}{\hbar \omega} + \frac{1}{2} \right) \ln \left(\frac{u}{\hbar \omega} + \frac{1}{2} \right) - \left(\frac{u}{\hbar \omega} - \frac{1}{2} \right) \ln \left(\frac{u}{\hbar \omega} - \frac{1}{2} \right)$$