Формули – твърдо тяло

$$\Psi(\vec{r},t) = e^{-i\frac{Et}{\hbar}}\psi(\vec{r})$$

$$E = \frac{\hbar^2 k^2}{2m}$$

$$p = \hbar k$$

$$\psi(x) = Ae^{ikx} + Be^{-ikx}$$

$$k = \sqrt{\frac{2mE}{\hbar^2}}$$

$$E_n = \frac{\pi^2\hbar^2 n^2}{2ma^2}$$

$$\psi_n(x) = \sqrt{\frac{2}{a}}\sin\left(\frac{n\pi x}{a}\right)$$

$$\psi_{n_x n_y n_z}(x,y,z) = \sqrt{\frac{2^3}{abc}}\sin\left(\frac{n_x\pi x}{a}\right)\cdot \sin\left(\frac{n_y\pi y}{b}\right)\cdot\sin\left(\frac{n_z\pi z}{b}\right)$$

$$E_{n_x n_y n_z} = \frac{\pi^2\hbar^2}{2m}\left[\left(\frac{n_x}{a}\right)^2 + \left(\frac{n_y}{b}\right)^2 + \left(\frac{n_z}{c}\right)^2\right]$$

$$dN = (2l+1)\cdot\frac{1}{8}\cdot 4\pi n^2 dn$$

$$dN = (2l+1)2\pi V\frac{(2m)^{3/2}}{(2\pi\hbar)^3}E^{1/2}dE$$

$$dN = (2l+1)\frac{4\pi V}{\lambda^4}d\lambda$$

$$D \sim e^{\left[-\frac{2}{\hbar}\sqrt{2m(U_0-E)}a\right]}$$

$$E_n = \left(n+\frac{1}{2}\right)\hbar\omega \quad (n = 0, 1, 2, ...)$$

$$L = \hbar\sqrt{l(l+1)}$$

$$L_z = m\hbar$$

$$E = -\mu_z B = -L_z\mu_B g B = -g\mu_B B m$$

$$\psi_s(x_1,x_2) = \sqrt{\frac{1}{2}}\left[\psi_{n_1}(x_1)\psi_{n_2}(x_2) + \psi_{n_1}(x_2)\psi_{n_2}(x_1)\right]$$

$$\psi_a(x_1,x_2) = \sqrt{\frac{1}{2}}\left[\psi_{n_1}(x_1)\psi_{n_2}(x_2) - \psi_{n_1}(x_2)\psi_{n_2}(x_1)\right]$$

$$\begin{aligned}\psi &= \psi_a(x_1,x_2)\chi_1^-\chi_2^- \\ \psi &= \psi_a(x_1,x_2)(\chi_1^+\chi_2^- + \chi_2^+\chi_1^-) \\ \psi &= \psi_a(x_1,x_2)\chi_1^+\chi_2^+\end{aligned}$$

$$\langle E\rangle = \frac{\sum_{n=1}^{\infty} E_n e^{-E_n/kT}}{\sum_{n=1}^{\infty} e^{-E_n/kT}}$$

$$\langle E\rangle = \frac{h\nu}{e^{h\nu/kT - 1}} = \frac{2\pi\hbar c}{\lambda}\frac{1}{e^{2\pi\hbar c/kT\lambda}-1}$$

$$u_\lambda(T) = \frac{16\pi^2\hbar c}{\lambda^5}\frac{1}{e^{2\pi\hbar c/kT\lambda}-1}$$

$$e_\lambda = \frac{c}{4}u_\lambda(T)$$

$$e_\lambda = \frac{4\pi^2\hbar c^2}{\lambda^5}\frac{1}{e^{2\pi\hbar c/kT\lambda}-1}$$

$$P_{mn} = B_{nm}u_\lambda$$

$$N_{mn} = P_{mn}N_m = B_{mn}u_\lambda N_m$$

$$\frac{N_m}{N_n} = e^{\frac{(E_n - E_m)}{kT}} = e^{h\nu/kT} = e^{hc/kT\lambda}$$

$$N_n = N_{n0}e^{-A_{nm}t} = N_{n0}e^{-\frac{t}{\tau_n}}$$

$$\frac{N_{mn}^{\text{погл.}}}{N_{nm}^{\text{изл.}}} = \frac{N_m}{N_n} = e^{\frac{(E_n-E_m)}{kT}}$$

$$\lambda' - \lambda = \lambda_c(1-\cos\theta)$$

$$g(E) = 4\pi V \frac{(2m)^{3/2}}{(2\pi\hbar)^3} E^{1/2}$$

$$N = \int_0^{E_F(0)} g(E)dE$$

$$E_F(0) = \frac{\hbar^2}{2m}(3\pi^2 n)^{3/2}$$

$$< E >= \frac{1}{N}\int_0^{E_F(0)} g(E)EdE$$

$$< E >= \frac{3}{5}E_F(0)$$

$$f(E) = \frac{1}{e^{(E-\mu)/kT} \pm 1}$$

$$N = \int_0^{\infty} g(E)f(E)dE$$

$$E_F = E_F(0)\left[1 - \frac{\pi^2}{12}\left(\frac{kT}{E_F(0)}\right)^2\right]$$

$$m\frac{d^2x_n}{dt^2} = K(x_{n+1}-x_n) - K(x_n - x_{n-1})$$

$$\omega = 2\omega_0\left|\sin\frac{ka}{2}\right|$$

$$\begin{aligned} M\frac{d^2y_n}{dt^2} &= K(x_{n+1}-y_n) - K(y_n - x_n) \\ m\frac{d^2x_n}{dt^2} &= K(y_n - x_n) - K(y_{n-1} - x_n) \end{aligned}$$

$$\omega^2 = \omega_1^2 + \omega_2^2 \pm \sqrt{(\omega_1^2+\omega_2^2)^2 - 4\omega_1^2\omega_2^2\sin^2\frac{ka}{2}}$$

$$g(\omega) = \frac{dN}{d\omega} = \frac{3}{2}\frac{V}{\pi^2}\frac{\omega^2}{v^3}$$

$$3N = \int_0^{\omega_D} g(\omega)d\omega = \int_0^{\omega_D}\frac{3}{2}\frac{V}{\pi^2}\frac{\omega^2}{v^3}d\omega = V\frac{\omega_D^3}{2\pi^2 v^3}$$

$$E = \int_0^{\omega_D}\hbar\omega g(\omega)d\omega = \int_0^{\omega_D}\left(\frac{\hbar\omega}{e^{\hbar\omega/kT-1}}\right) 9n\frac{\omega^2}{\omega_D}d\omega$$

$$E = 9nk\Theta_D\left(\frac{T}{\Theta_D}\right)^4 \int_0^{\Theta_D/T}\frac{x^3dx}{e^x - 1}$$

$$\int_0^{\infty}\frac{x^3dx}{e^x-1} = \frac{\pi^4}{15}$$

$$E = \frac{3\pi^4}{5}nk\Theta_D\left(\frac{T}{\Theta_D}\right)^4$$

$$C_V = \frac{12\pi^4}{5}nk\left(\frac{T}{\Theta_D}\right)^3$$

$$E = 9nk\Theta_D\left(\frac{T}{\Theta_D}\right)^4\int_0^{\Theta_D/T}\frac{x^3dx}{(1+x+x^2\cdots -1)}$$

$$C_V = C_{реш.} + C_e$$

$$E_e^{кл.} = N_A\frac{3}{2}kT = \frac{3}{2}RT$$

$$\frac{\Delta N}{N} \sim \frac{kT}{2E_F}$$

$$C_e = \pi^2 nk\frac{kT}{2E_F}$$

$$\lambda_{ф} = \frac{1}{n_{ф}\sigma} \sim \frac{1}{n_{ф} g^2}$$

$$\kappa = \frac{1}{3}\lambda v C_V$$

$$\kappa = \kappa_{реш.} + \kappa_e$$

$$\kappa_e = \frac{\pi^2}{3}\frac{nk^2}{2E_F}v_F\lambda_e T = \frac{\pi^2}{3}\frac{nk^2}{mv_F}\lambda_e T$$

$$\psi(x) = e^{ikx}u_k(x)$$

$$U(x) = V\sum_{m=-\infty}^{+\infty}\delta(x - ma)$$

$$\delta(x-a)=\begin{cases}0 & x\neq a\\ \infty & x=a\end{cases}$$

$$\int_{-\infty}^{\infty}\delta(x)dx=1$$

$$\int_{-\infty}^{\infty}\delta(x-a)f(x)dx=f(a)$$

$$\cos(ka)=\cos(\beta a)+p\frac{\sin(\beta a)}{\beta a}$$

$$f(x)=\cos x+p\frac{\sin x}{x},\qquad x=\beta a$$

$$\psi_k(x)=C\sum_{-\infty}^{\infty}e^{ikan}\psi_0(x-an)$$

$$E_s(k)=E_{0s}+2A_s\cos(ka)$$

$$E_p(k)=E_{0p}-2A_p\cos(ka)$$

$$E_{\text{в}}(k)=E_{max}+A_{\text{д}}(ka)^2$$

$$E_{\text{д}}(k)=E_{min}-A_{\text{в}}(ka)^2$$

$$m_{e\text{ф}}=\frac{\hbar^2}{2A_{\text{д}}a^2}$$

$$\vec{j}=\sigma\vec{E}$$

$$\sigma=\frac{ne^2\lambda_e\bar{v}}{m\bar{v}}$$

$$\frac{\kappa}{\sigma}=\frac{\pi^2}{3}\left(\frac{k}{e}\right)^2T$$

$$\sigma_{e\text{ф}}=\pi A^2\sim T,\quad \lambda_e\sim\frac{1}{\sigma_{e\text{ф}}}\sim\frac{1}{T}$$

$$f(E)=\frac{1}{e^{(E-\mu)/kT}+1}\approx e^{-(E-\mu)/kT}$$

$$dN=g(E)f(E)dE=4\pi V\frac{(2m)^{3/2}}{(2\pi\hbar)^3}E^{1/2}e^{\mu/kT}e^{-E/kT}dE$$

$$n=4\pi\frac{(2m)^{3/2}}{(2\pi\hbar)^3}e^{\mu/kT}\int_0^{\infty}e^{-E/kT}\sqrt{E}dE$$

$$n=4\pi\frac{(2m)^{3/2}}{(2\pi\hbar)^3}e^{\mu/kT}(kT)^{3/2}2\int_0^{\infty}x^2e^{-x}dx$$

$$n=2\left(\frac{2\pi mkT}{h^2}\right)^{3/2}e^{\mu/kT}$$

$$f_e(E)+f_p(E)=1$$

$$f_p(E)=\frac{1}{e^{(\varepsilon-\mu')/kT}+1}$$

$$p=2\left(\frac{2\pi m_pkT}{h^2}\right)^{3/2}e^{\mu'/kT}$$

$$\mu=-\frac{E_g}{2}+\frac{3}{4}kT\ln\frac{m_p}{m_n}$$

$$n=p=2\left(\frac{2\pi\sqrt{m_nm_p}\,kT}{h^2}\right)^{3/2}e^{-E_g/2kT}$$

$$\mu=-\frac{E_g}{2}+\frac{kT}{2}\ln\left[\frac{n_dh^3}{2(2\pi m_nkT)^{3/2}}\right]$$

$$\mu=-\frac{E_g}{2}+\frac{kT}{2}\ln\left[\frac{n_ah^3}{2(2\pi m_pkT)^{3/2}}\right]$$

$$n=\sqrt{2n_d}\left(\frac{2\pi\sqrt{m_nm_p}\,kT}{h^2}\right)^{3/2}e^{-E_d/2kT}$$

$$p=\sqrt{2n_a}\left(\frac{2\pi\sqrt{m_nm_p}\,kT}{h^2}\right)^{3/2}e^{-E_a/2kT}$$

$$V_k=\frac{(U_{01}-U_{02})}{e},\quad V_i=\frac{(E_{F_2}-E_{F_2})}{e}$$

$$I=I_s(e^{eV/kT}-1)$$

$$j_D^p+j_D^n=j_E^p+j_E^n$$

$$\vec{B}=\mu_0(\vec{H}+\vec{H}_i)$$

$$\vec{H}_i=\chi\vec{H},$$

$$\vec{B}=\mu_0(1+\chi)\vec{H}=\mu_0\mu_r\vec{H}$$

$$\chi=\frac{C}{T-\Theta}$$

$$E=-J\vec{S}_1\cdot\vec{S}_2$$

$$\Phi=n\frac{2\pi\hbar}{q}$$