$$n_0 = N_c e^{-\frac{(E_c - E_f)}{kT}} = n_i e^{\frac{E_f - E_i}{kT}}$$

$$P_0 = N_v e^{-\frac{E_f - E_v}{kT}} = n_i e^{\frac{E_i - E_f}{kT}}$$

$$n_i = \sqrt{N_c N_v}\, e^{-\frac{E_g}{2kT}}$$

$$N_c = 2\left(\frac{2\pi m_n^* KT}{h^2}\right)^{\frac{3}{2}}$$

$$N_v = 2\left(\frac{2\pi m_p^* KT}{h^2}\right)^{\frac{3}{2}}$$

$$n_i^2 = n_0 p_0$$

$$I(x) = I_0 e^{-\alpha x}$$

$$g_{th} = \alpha_r n_0 p_0$$

$$g_{op} = \alpha_r (n_0 + p_0)\delta_n + \alpha_r \delta^2 n$$

$$\tau = \frac{1}{\alpha_r (n_0 + p_0)}$$

$$f(E) = \frac{1}{1 + e^{\frac{(E - E_f)}{KT}}}$$

$$f(E_d) = \frac{1}{1 + \frac{1}{2} e^{\frac{(E_d - E_f)}{KT}}}$$

$$f(E_a) = \frac{1}{1 + \frac{1}{4} e^{\frac{(E_a - E_f)}{KT}}}$$

$$\frac{D}{\mu} = \frac{KT}{q}$$

$$L_p = \sqrt{D_p \tau_p}$$

$$\sigma = q(n\mu_n + p\mu_p)$$

$$\varepsilon(x) = \frac{1}{q}\frac{dE_i}{dx}$$

$$J_n(x) = q\mu_n n(x)\,\varepsilon(x) + qD_n \frac{d}{dx} n(x)$$

$$J_p(x) = q\mu_p p(x)\,\varepsilon(x) - qD_p \frac{d}{dx} p(x)$$

$$\frac{\partial p}{\partial t} = \frac{-1}{q}\frac{\partial J_p}{\partial x} - \frac{\delta_p}{\tau_p} + g_p$$

$$\frac{\partial n}{\partial t} = \frac{1}{q}\frac{\partial J_n}{\partial x} - \frac{\delta_n}{\tau_n} + g_n$$

$$\frac{d\varepsilon(x)}{dx} = \frac{-d^2 v(x)}{dx^2} = \frac{\rho}{\varepsilon}$$

$$\rho = q(p - n + N_d^+ - N_a^-)$$

$$\frac{\partial p}{\partial t} = D_p \frac{\partial^2 p}{\partial x^2} - \frac{\delta_p}{\tau_p} + g_p$$

$$\frac{\partial n}{\partial t} = D_n \frac{\partial^2 n}{\partial x^2} - \frac{\delta_n}{\tau_n} + g_n$$

$$E_n = \left(\frac{h^2 n^2}{8mL^2}\right) = \frac{h^2 k^2}{8\pi^2 m}$$

$$N_A = 6.02 \times 10^{23} \quad 1/\text{mol}$$

$$K = 1.38 \times 10^{-23} \quad J/°k$$

$$= 8.62 \times 10^{-5} \quad ev/°k$$

$$q = 1.60 \times 10^{-19} \quad c$$

$$m_0 = 9.11 \times 10^{-31} \quad kg$$

$$\varepsilon_0 = 8.85 \times 10^{-14} \quad F/cm$$

$$= 8.85 \times 10^{-12} \quad F/m$$

$$h = 6.63 \times 10^{-34}\ J - \text{sec}$$

$$= 4.14 \times 10^{-15}\ eV - \text{sec}$$

$$KT = 0.0259\ eV$$

$$c = 2.998 \times 10^{10}\ cm/\text{sec}$$

$$E_f = \frac{\pi^2 \hbar^2}{2m}\left(\frac{3}{\pi} \cdot \frac{N}{V}\right)^{\frac{2}{3}}$$