Equation Sheet

$h = 6.626\times10^{-34}$ J-s

$\hbar = 1.055\times10^{-34}$ J-s

$q = 1.602\times10^{-19}\,\mathrm{C}$

$m_0 = 9.11\times10^{-31}\,\mathrm{kg}$

$k = 8.617\times10^{-5}$ eV/K

$\varepsilon_0 = 8.854\times10^{-14}\,\mathrm{F/cm}$

$eV = 1.602\times10^{-19}\,\mathrm{J}$

$$\frac{d^2V}{dx^2} = -\frac{\rho}{K_s\varepsilon_0}$$

$$\mathscr{E} = -\frac{dV}{dx} = \frac{1}{q}\frac{dE}{dx}$$

$$E = \frac{\hbar^2k^2}{2m^*} + V_0$$

$$g_c(E) = \frac{m_n^*\sqrt{2m_n^*(E-E_\mathrm{C})}}{\pi^2\hbar^3}, \quad E \ge E_\mathrm{C}$$

$$g_v(E) = \frac{m_\mathrm{p}^*\sqrt{2m_\mathrm{p}^*(E_\mathrm{V}-E)}}{\pi^2\hbar^3}, \quad E \le E_\mathrm{V}$$

$$f(E) = \frac{1}{1+\exp\left(\frac{E-E_\mathrm{F}}{kT}\right)}$$

Boltzman approx:

$$f(E) = \exp\left(-\frac{E-E_\mathrm{F}}{kT}\right)$$

$$E_\mathrm{F} = E_\mathrm{C} + kT\ln\left(\frac{n}{N_\mathrm{C}}\right)$$

$$E_\mathrm{F} = E_\mathrm{V} - kT\ln\left(\frac{p}{N_\mathrm{V}}\right)$$

$$E_\mathrm{i} - E_\mathrm{F} = kT\ln\left(\frac{p}{n_\mathrm{i}}\right)$$

$$E_\mathrm{i} = \frac{E_\mathrm{C}+E_\mathrm{V}}{2} + \frac{3}{4}kT\ln\left(\frac{m_\mathrm{p}^*}{m_\mathrm{n}^*}\right)$$

$$n_i = \sqrt{N_C N_V}\,\exp\left(-\frac{E_\mathrm{G}}{2kT}\right)$$

$$n = n_\mathrm{i}\exp\left(\frac{E_\mathrm{F}-E_\mathrm{i}}{kT}\right)$$

$$n = N_\mathrm{C}\exp\left(\frac{E_\mathrm{F}-E_\mathrm{C}}{kT}\right)$$

$$p = n_\mathrm{i}\exp\left(-\frac{E_\mathrm{F}-E_\mathrm{i}}{kT}\right)$$

$$p = N_\mathrm{V}\exp\left(\frac{E_\mathrm{V}-E_\mathrm{F}}{kT}\right)$$

$$np = n_\mathrm{i}^2$$

$$n - N_D^+ - p + N_A^- = 0$$

$$n = \frac{N_\mathrm{D}-N_\mathrm{A}}{2} + \sqrt{\left(\frac{N_\mathrm{D}-N_\mathrm{A}}{2}\right)^2 + n_\mathrm{i}^2}$$

$$p = \frac{N_\mathrm{A}-N_\mathrm{D}}{2} + \sqrt{\left(\frac{N_\mathrm{A}-N_\mathrm{D}}{2}\right)^2 + n_\mathrm{i}^2}$$

$$\rho = \frac{1}{nq\mu_\mathrm{n} + pq\mu_\mathrm{p}}$$

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

$$J_\mathrm{p} = q\mu_\mathrm{p}p\mathscr{E} - qD_\mathrm{p}\frac{dp}{dx}$$

$$J_\mathrm{n} = q\mu_\mathrm{n}n\mathscr{E} + qD_\mathrm{n}\frac{dn}{dx}$$

$$\frac{\partial\Delta n_\mathrm{p}}{\partial t} = D_n\frac{\partial^2\Delta n_\mathrm{p}}{\partial x^2} - \frac{\Delta n_\mathrm{p}}{\tau_n} + G$$

$$\frac{\partial\Delta p_\mathrm{n}}{\partial t} = D_p\frac{\partial^2\Delta p_\mathrm{n}}{\partial x^2} - \frac{\Delta p_\mathrm{n}}{\tau_p} + G$$

$$L_N = \sqrt{D_N\tau_n}$$

$$L_P = \sqrt{D_P\tau_p}$$

$$V_{bi} = \frac{kT}{q}\ln\left(\frac{N_\mathrm{D}N_\mathrm{A}}{n_\mathrm{i}^2}\right)$$

$$W = \sqrt{\frac{2K_s\varepsilon_0(V_{bi}-V_\mathrm{A})}{q}\left(\frac{N_\mathrm{A}+N_\mathrm{D}}{N_\mathrm{A}N_\mathrm{D}}\right)}$$

$$x_N(V_{bi}) = \sqrt{\frac{2K_s\varepsilon_0(V_{bi}-V_\mathrm{A})}{q}\left(\frac{N_\mathrm{A}}{N_\mathrm{D}(N_\mathrm{A}+N_\mathrm{D})}\right)}$$

$$x_P\left(V_{bi}\right) = \sqrt{\frac{2K_s\varepsilon_0\left(V_{bi}-V_A\right)}{q}\left(\frac{N_D}{N_A\left(N_A+N_D\right)}\right)}$$

$$I = qA\left(\frac{D_N}{L_N}\frac{n_i^2}{N_A}+\frac{D_P}{L_P}\frac{n_i^2}{N_D}\right)\left(e^{qV_A/kT}-1\right)$$

$$I = I_0\left(e^{qV_A/kT}-1\right)$$

$$np = n_i^2 e^{qV_A/kT}, -x_p \le x \le x_n$$

$$p = n_\mathrm{i}\exp\left(\frac{E_\mathrm{i}-F_p}{kT}\right)$$

$$n = n_i\exp\left(\frac{F_n-E_i}{kT}\right)$$

$$F_n = E_\mathrm{i}+kT\ln\left(\frac{n}{n_\mathrm{i}}\right)$$

$$F_p = E_\mathrm{i}-kT\ln\left(\frac{p}{n_\mathrm{i}}\right)$$

Table of properties of selected semiconductors (at 300K)

| Property | Si | Ge | GaAs |
|---|---|---|---|
| $N_C$ (cm$^{-3}$) | $3.20\times10^{19}$ | $1.02\times10^{19}$ | $4.34\times10^{17}$ |
| $N_V$ (cm$^{-3}$) | $1.82\times10^{19}$ | $5.40\times10^{18}$ | $9.37\times10^{18}$ |
| $n_i$(cm$^{-3}$) | $10^{10}$ | $2.3\times10^{13}$ | $2.25\times10^{6}$ |
| $E_G$(eV) | 1.12 | 0.66 | 1.42 |
| $m_n^*/m_0$ | 1.18 | 0.55 | 0.067 |
| $m_p^*/m_0$ | 0.81 | 0.36 | 0.52 |
| $K_S$ | 11.8 | 16 | 13.1 |