Cheat Sheet

Constants

$N_A = 6.02 \times 10^{23}$ molecules/mole
$k = 1.38 \times 10^{-23}$ J/K
$= 8.62 \times 10^{-5}$ ev/K
$q = 1.60 \times 10^{-19}$ C
$m_0 = 9.11 \times 10^{-31}$ kg
$\epsilon_0 = 8.85 \times 10^{-14}$ F/cm
$h = 6.63 \times 10^{-34}$ Js
$= 4.14 \times 10^{-15}$ eVs
$kT = 0.0259$ eV
$c = 2.998 \times 10^{10}$ cm/s
$\mathring{A} = 10^{-8}$ cm
1 eV $= 1.6 \times 10^{-19}$ J

Formulas

$p = mv = \hbar\vec{k} = \frac{h}{\lambda}$
$E = hv = \hbar\omega$
$E = \frac{1}{2}mv^2 = \frac{1}{2}\frac{p^2}{m} = \frac{\hbar}{2m^*}\vec{k}^2$
$m^* = \frac{\hbar^2}{\frac{d^2E}{d\vec{k}^2}}$
$E_N = KE + PE = E_c + E(k) = -\frac{mq^4}{K^2n^2\hbar^2}$

	Classical Mechanics	Quantum Mechanics
Position	x	x
Momentum	$p = mv$	$\frac{\hbar}{j}\frac{\partial}{\partial x}$
Energy	$E = KE + PE = \frac{1}{2}mv^2 + PE$	$-\frac{\hbar}{j}\frac{\partial}{\partial t}$

$\langle Q \rangle = \int\limits_{-\infty}^{\infty} \psi^* Q_{op} \psi \, d\vec{x}$
$Eg(x) = \int\limits_{-\infty}^{\infty} g(x)P(x)dx$

$f(E) = \frac{1}{e^{(E-E_F)/kT}+1} \approx e^{(E_F-E)/kT}$
$n_0 = N_c f(E_C)$
$N_c = 2(\frac{2\pi m_n^* kT}{h^2})^{3/2}$
$N_v = 2(\frac{2\pi m_p^* kT}{h^2})^{3/2}$
$p_0 = N_v f(E_v)$

$L = \sqrt{D\tau}$
$\rho = \frac{1}{\sigma}$
$R = \frac{\rho L}{wt}$
$J = \frac{I}{A}$
$J = J_n + J_p + C\frac{dV}{dt} = \sigma\varepsilon$

$n_i = N_c e^{-(E_C - E_i)/kT} = \sqrt{N_c N_v} e^{-E_g/2kT}$
$p_i = N_v e^{-(E_i - E_C)/kT}$
$E = \frac{mq^4}{2K^2\hbar^2}$

$J_n(x) = q\mu_n n(x)\varepsilon(x) + qD_n \frac{dn(x)}{dx}$
$J_p(x) = q\mu_p p(x)\varepsilon(x) - qD_p \frac{dp(x)}{dx}$
$\frac{kT}{q} = \frac{D}{\mu}$

Equilibrium

$n_0 = n_i e^{(E_F - E_i)/kT}$
$p_0 = n_i e^{(E_i - E_F)/kT}$
$n_0 p_0 = n_i^2$

Steady State

$n = N_c e^{-(E_C - F_n)/kT} = n_i e^{(F_n - E_i)/kT}$
$p = N_v e^{-(F_p - E_v)/kT} = n_i e^{(E_i - F_p)/kT}$
$np = n_i^2 e^{(F_n - F_p)/kT}$

Potential Well

$\psi = A \sin Kx$
$K = \frac{\sqrt{2mE}}{\hbar}$

$\psi_H = \sqrt{\frac{2}{L}} \sin \frac{nm}{L} x$
$\psi_K(X) = U(k_x, x) e^{jKxX}$

p-n

$V_0 = \frac{kT}{q} \ln\left(\frac{N_a N_d}{n_i^2}\right)$
$\frac{p_p}{p_n} = \frac{n_n}{n_p} = e^{qV_0/kT}$
$W = \sqrt{\frac{2\epsilon(V_0 - V)}{q}\left(\frac{N_a + N_d}{N_a N_d}\right)}$
$n = n_0 + \delta_n$
$p = p_0 + \delta_p$
$\delta_p(x_n) = \Delta p_n e^{-x_n/L_p}$
$\delta_n(x_p) = \Delta n_p e^{-x_p/L_n}$

$Q_+ = qAx_{n0}N_d = qAx_{p0}N_a$
$\varepsilon_0 = -\frac{q}{\varepsilon} x_{n0} N_d = -\frac{q}{\varepsilon} x_{p0} N_a$
$I_p = qA\frac{D_p}{L_p} p_n (e^{qV/kT} - 1)$
$I_n = qA\frac{D_n}{L_n} n_p (e^{qV/kT} - 1)$
$I_{op} = qAg_{op}(L_p + L_n + W)$
$\Delta\sigma = qg_{op}(\tau_n \mu_n + \tau_p \mu_p)$

One sided

$x_{p0} = W\frac{N_d}{N_a + N_d}$
$x_{n0} = W\frac{N_a}{N_a + N_d}$