Cheat Sheet

Constants

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

Formulas

$$egin{aligned} p &= mv = \hbar ec{k} = rac{h}{\lambda} \ E &= hv = \hbar \omega \ E &= rac{1}{2} m v^2 = rac{1}{2} rac{p^2}{m} = rac{\hbar}{2m^*} ec{k}^2 \ m^* &= rac{\hbar^2}{d^2 E} \ E_N &= KE + PE = E_c + E(k) = -rac{mq^4}{K^2 n^2 \hbar^2} \end{aligned}$$

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

$$egin{aligned} \langle Q
angle &= \int\limits_{-\infty}^{\infty} \psi^* Q_{op} \psi \ dec{x} \ Eg(x) &= \int\limits_{-\infty}^{\infty} g(x) P(x) dx \ f(E) &= rac{1}{e^{(E-E_F)/kT}+1} pprox e^{(E_F-E)/kT} \ n_0 &= N_c f(E_C) \ N_c &= 2 (rac{2\pi m_n^* kT}{h^2})^{3/2} \ N_v &= 2 (rac{2\pi m_p^* kT}{h^2})^{3/2} \ p_0 &= N_v f(E_v) \end{aligned}$$

$$egin{aligned} n_i &= N_c e^{-(E_C-E_i)/kT} = \sqrt{N_c N_v} e^{-E_g/2kT} \ p_i &= N_v e^{-(E_i-E_C)/kT} \ E &= rac{mq^4}{2K^2\hbar^2} \ L &= \sqrt{D au} \
ho &= rac{1}{\sigma} \ R &= rac{
ho L}{wt} \ J &= rac{I}{A} \ J &= J_n + J_p + Crac{dV}{dt} = \sigma arepsilon \ J_p(x) &= q \mu_n n(x) arepsilon(x) + q D_n rac{dn(x)}{dx} \ J_p(x) &= q \mu_p p(x) arepsilon(x) - q D_p rac{dp(x)}{dx} \ rac{kT}{a} &= rac{D}{\mu} \end{aligned}$$

Equilibrium

$$egin{aligned} n_0 &= n_i e^{(E_F-E_i)/kT} \ p_0 &= n_i e^{(E_i-E_F)/kT} \ n_0 p_0 &= n_i^2 \end{aligned}$$

Steady State

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

Potential Well

 $\psi = A \sin Kx$

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

p-n

$$egin{aligned} V_0 &= rac{kT}{q} \mathrm{ln} \left(rac{N_a N_d}{n_i^2}
ight) \ rac{p_p}{p_n} &= rac{n_n}{n_p} = e^{qV_0/kT} \ W &= \sqrt{rac{2\epsilon(V_0 - V)}{q} \left(rac{N_a + N_d}{N_a N_d}
ight)} \end{aligned}$$

$$egin{aligned} n &= n_0 + \delta_n \ p &= p_0 + \delta_p \ \delta_p(x_n) &= \Delta p_n e^{-x_n/L_p} \ \delta_n(x_p) &= \Delta n_p e^{-x_p/L_n} \end{aligned}$$

$$egin{aligned} Q_{+} &= qAx_{n0}N_{d} = qAx_{p0}N_{a} \ arepsilon_{0} &= -rac{q}{arepsilon}x_{n0}N_{d} = -rac{q}{arepsilon}x_{p0}N_{a} \ &I_{p} &= qArac{D_{p}}{L_{p}}p_{n}(e^{qV/kT}-1) \ &I_{n} &= qArac{D_{n}}{L_{n}}n_{p}(e^{qV/kT}-1) \ &I_{op} &= qAg_{op}(L_{p}+L_{n}+W) \ &\Delta\sigma &= qg_{op}(au_{n}\mu_{n}+ au_{p}\mu_{p}) \end{aligned}$$

One sided

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