Cheat Sheet

Constants

$N_A=6.02 imes10^{23}\ { m molecules/mole}$
$k = 1.38 imes 10^{-23} \ { m J/K}$
$=8.62 imes10^{-5}~\mathrm{ev/K}$
$q = 1.60 imes 10^{-19} \; ext{C}$
$m_0 = 9.11 imes 10^{-31} \ { m kg}$
$\epsilon_0 = 8.85 imes 10^{-14}~\mathrm{F/cm}$
Si: $\epsilon_r=11.8$
SiO2: $\epsilon_r=3.9$

$$h=6.63 imes 10^{-34} ext{ Js}$$
 $=4.14 imes 10^{-15} ext{ eVs}$ $kT=0.0259 ext{ eV}$ $c=2.998 imes 10^{10} ext{ cm/s}$ $ext{Å}=10^{-8} ext{ cm}$ $1 ext{ eV}=1.6 imes 10^{-19} ext{ J}$ Si: $E_q=1.12 ext{ eV}$

Si: $\phi_m pprox \chi = 4.05~eV$

Formulas

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

$$egin{align*} p &= mv = \hbar ec{k} = rac{h}{\lambda} \ E &= hv = \hbar \omega \ E &= rac{1}{2} m v^2 = rac{1}{2} rac{p^2}{m} = rac{\hbar}{2m^*} ec{k}^2 \ m^* &= rac{\hbar^2}{rac{d^2E}{dk^2}} \ f(E) &= rac{1}{e^{(E-E_F)/kT} + 1} pprox e^{(E_F-E)/kT} \ n_0 &= N_c f(E_C) \ N_c &= 2 (rac{2\pi m_p^* kT}{h^2})^{3/2} \ N_v &= 2 (rac{2\pi m_p^* kT}{h^2})^{3/2} \ p_0 &= N_v f(E_v) \ n_i &= N_c e^{-(E_C-E_i)/kT} = \sqrt{N_c N_v} e^{-E_g/2kT} \ p_i &= N_v e^{-(E_i-E_C)/kT} \ E &= rac{mq^4}{2K^2\hbar^2} \end{aligned}$$

Equilibrium

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

$$egin{aligned} E_N &= KE + PE = E_c + E(k) = -rac{mq^4}{K^2n^2\hbar^2} \ \langle Q
angle &= \int\limits_{-\infty}^{\infty} \psi^* Q_{op} \psi \ dec{x} \ Eg(x) &= \int\limits_{-\infty}^{\infty} g(x) P(x) dx \ L &= \sqrt{D au} \
ho &= rac{1}{\sigma} \ R &= rac{
ho L}{wt} \ J &= rac{I}{A} \ J &= J_n + J_p + Crac{dV}{dt} = \sigma arepsilon \ J_n(x) &= q \mu_n n(x) arepsilon(x) + q D_n rac{dn(x)}{dx} \ J_p(x) &= q \mu_p p(x) arepsilon(x) - q D_p rac{dp(x)}{dx} \ rac{kT}{a} &= rac{D}{\mu} \end{aligned}$$

Potential Well

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

Steady State

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

p-n

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

One sided

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

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

MOS

$$egin{aligned} rac{1}{2}\phi_s &= \phi_F = rac{kT}{q} \mathrm{ln}\left(rac{N_a}{n_i}
ight) = E_F - E_i \ W_{min} &= W igg|_{V_0 - V = \phi_s} \ C_i &= rac{\epsilon_i}{d} \ C_d &= rac{\epsilon_s}{W} \ C &= rac{C_i C_d}{C_i + C_d} \ V_{FB} &= \Phi_{ms} - rac{Q_i}{C_i} \ Q_d &= -q N_a W_m = -2 (\epsilon_s q N_a \phi_F)^{1/2} \ V_T &= V_{FB} - rac{Q_d}{C_i} + \Phi_s \ \Phi_s &= \chi + rac{E_g}{2} - \phi_F \end{aligned}$$