Equations for Exam #2

$$\tau_n = \frac{1}{\alpha_r(n_0+p_0)}$$
$$g_{op} = \alpha_r\left[(n_0+p_0)*\delta_n+\delta_n^2\right]$$
$$n_i^2 = p_0 * n_0$$
$$E_{F_n}-E_i = kT\ln\frac{n_n}{n_i} \approx kT\ln\frac{N_D^-}{n_i}$$
$$E_{F_p}-E_i = kT\ln\frac{p_p}{n_i} \approx kT\ln\frac{N_A^+}{n_i}$$

For n-type sample:

$$F_n - E_i = kT\ln\frac{n_n}{n_i},\ n_n = n_{n_0}+\delta_n$$
$$E_i - F_p = kT\ln\frac{p_n}{n_i},\ p_n = p_{n_0}+\delta_p$$
$$\sigma_n = q\left[\mu_p p_n + \mu_n n_n\right]$$

For p-type sample:

$$F_n - E_i = kT\ln\frac{n_p}{n_i},\ n_p = n_{p_0}+\delta_n$$
$$E_i - F_p = kT\ln\frac{p_p}{n_i},\ p_p = p_{p_0}+\delta_p$$
$$\sigma_p = q\left[\mu_p p_p + \mu_n n_p\right]$$

$$J = \sigma\vec{\varepsilon} \qquad (\text{if } \vec{\varepsilon} > \varepsilon_c, J = q(n+p)v_{sat})$$
$$D = \frac{kT}{q}\mu,\ L = \sqrt{D\tau}$$
$$qV_0 = (E_{F_n}-E_{F_p}) = kT\ln\frac{n_{n_0}p_{n_0}}{n_i^2}$$
$$\frac{p_p}{p_n} = \frac{n_n}{n_p} = e^{qV_0/kT}$$
$$\vec{\varepsilon}_0 \equiv \text{Max Field at Junction} = -\frac{q}{\epsilon_s}N_D x_{n_0} = -\frac{q}{\epsilon_s}N_A x_{p_0}$$
$$V_0 = -\frac{1}{2}\frac{q}{\epsilon} * \frac{N_A N_D}{N_A+N_D}W^2$$
$$W = \left[\frac{2\epsilon}{q}V_0\left(\frac{1}{N_A}+\frac{1}{N_D}\right)\right]^{1/2} = \left[\frac{2\epsilon}{q}(V_0-V)\left(\frac{1}{N_A}+\frac{1}{N_D}\right)\right]^{1/2} \text{ (with bias)}$$
$$\epsilon_s = \epsilon_{r_s}\epsilon_0$$

$$x_{p_0} = \frac{W}{1+\frac{N_A}{N_D}}, \qquad x_{n_0} = \frac{W}{1+\frac{N_D}{N_A}}$$
$$C_j = \frac{\epsilon_s}{W}(F/cm^2)$$
$$I = I_0(e^{V/V_T}-1);\ V_T = \frac{kT}{q}$$
$$I_0 = qA\left[\frac{D_p p_n}{L_p}+\frac{D_n n_p}{L_n}\right]$$
$$Q_+ = qAx_{n_0}N_D = qAx_{p_0}N_A$$
$$\delta n(x_p) = \Delta n_p e^{-x_p/L_n} = n_p(e^{V/V_T}-1)e^{-x_p/L_n}$$
$$\delta p(x_n) = \Delta p_n e^{-x_n/L_p} = p_n(e^{V/V_T}-1)e^{-x_n/L_p}$$
$$x_{p_0} = \left[\frac{2\epsilon}{q}V_0\left(\frac{N_D}{N_A(N_A+N_D)}\right)\right]^{1/2}$$
$$x_{n_0} = \left[\frac{2\epsilon}{q}V_0\left(\frac{N_A}{N_D(N_A+N_D)}\right)\right]^{1/2}$$

Constants:

$q = 1.6\times10^{-19}$C
$\epsilon_0 = 8.85\times10^{-14}$ Fm^{-1}, $\epsilon_{r_{Si}} = 11.8$
$h = 6.626\times10^{-34}$ m^{2}kg/s
$\hbar = \frac{h}{2\pi} = 1.055\times10^{-31}$ Js/rad
$m^* = 9.11\times10^{-31}$ kg
$kT|_{T=300K} \approx 0.026$ eV
$n_i(Si)|_{300K} = 1.5\times10^{10}$ cm^{-3}
v_{th} = Thermal Velocity $\approx 10^7$ cm/sec
$\vec{\varepsilon}_c$ = critical field = 10^4 V/cm

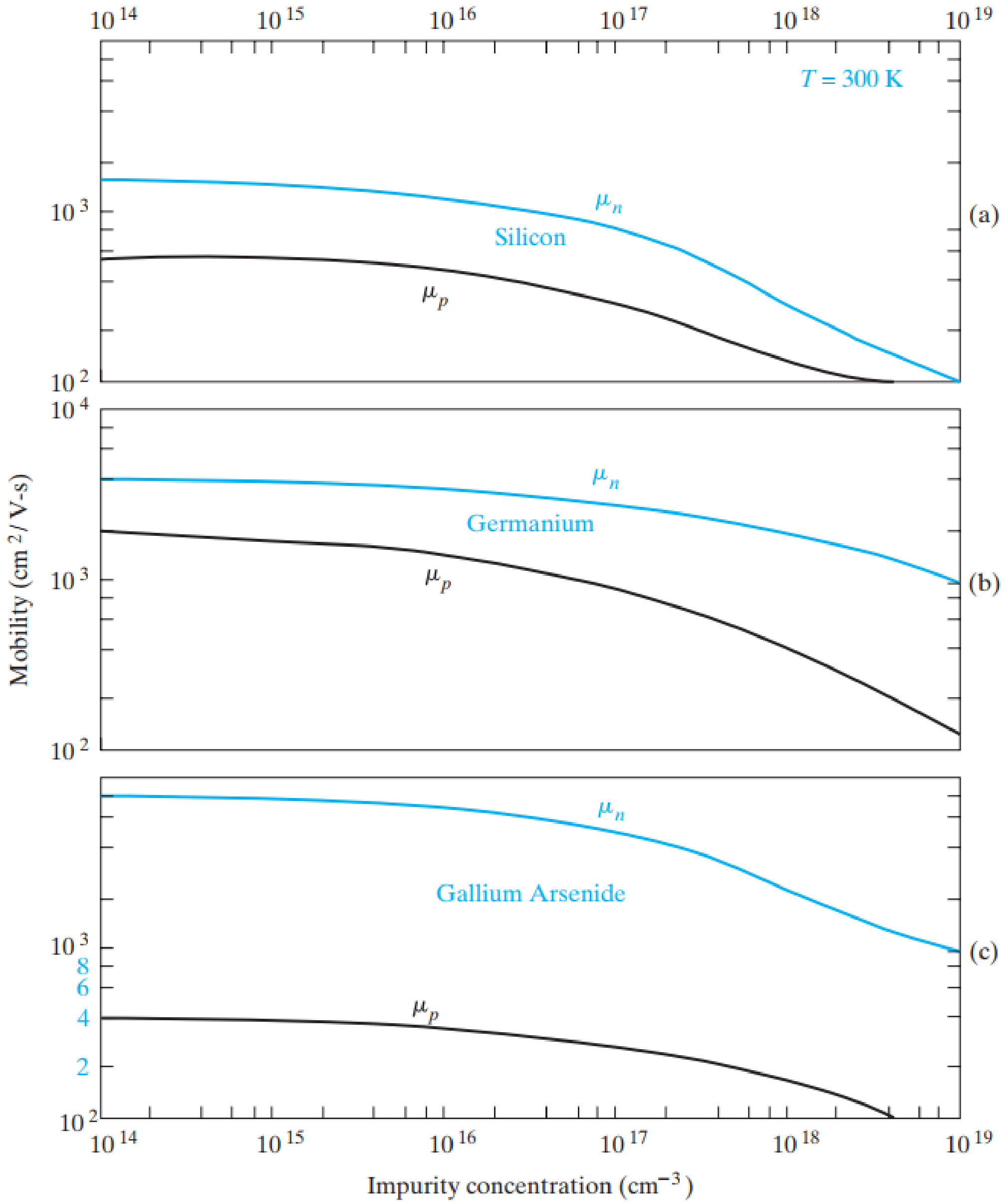
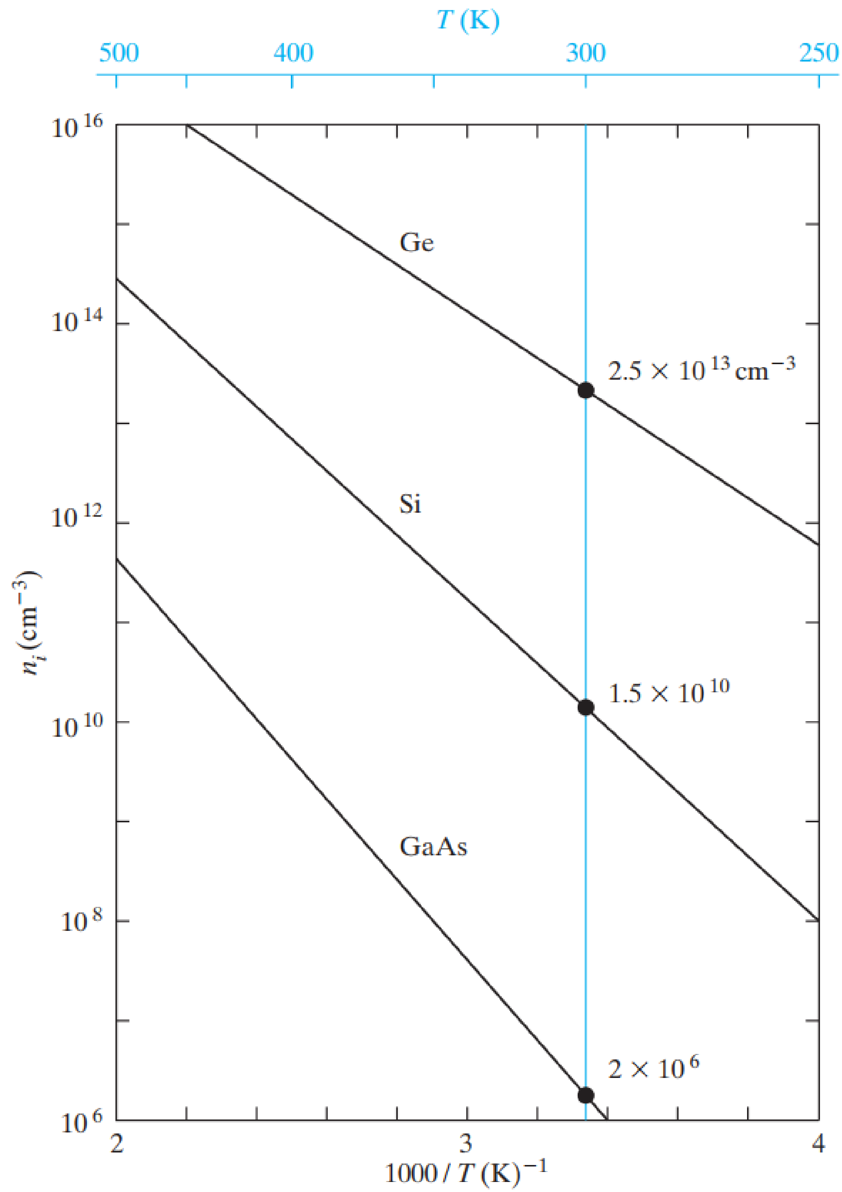
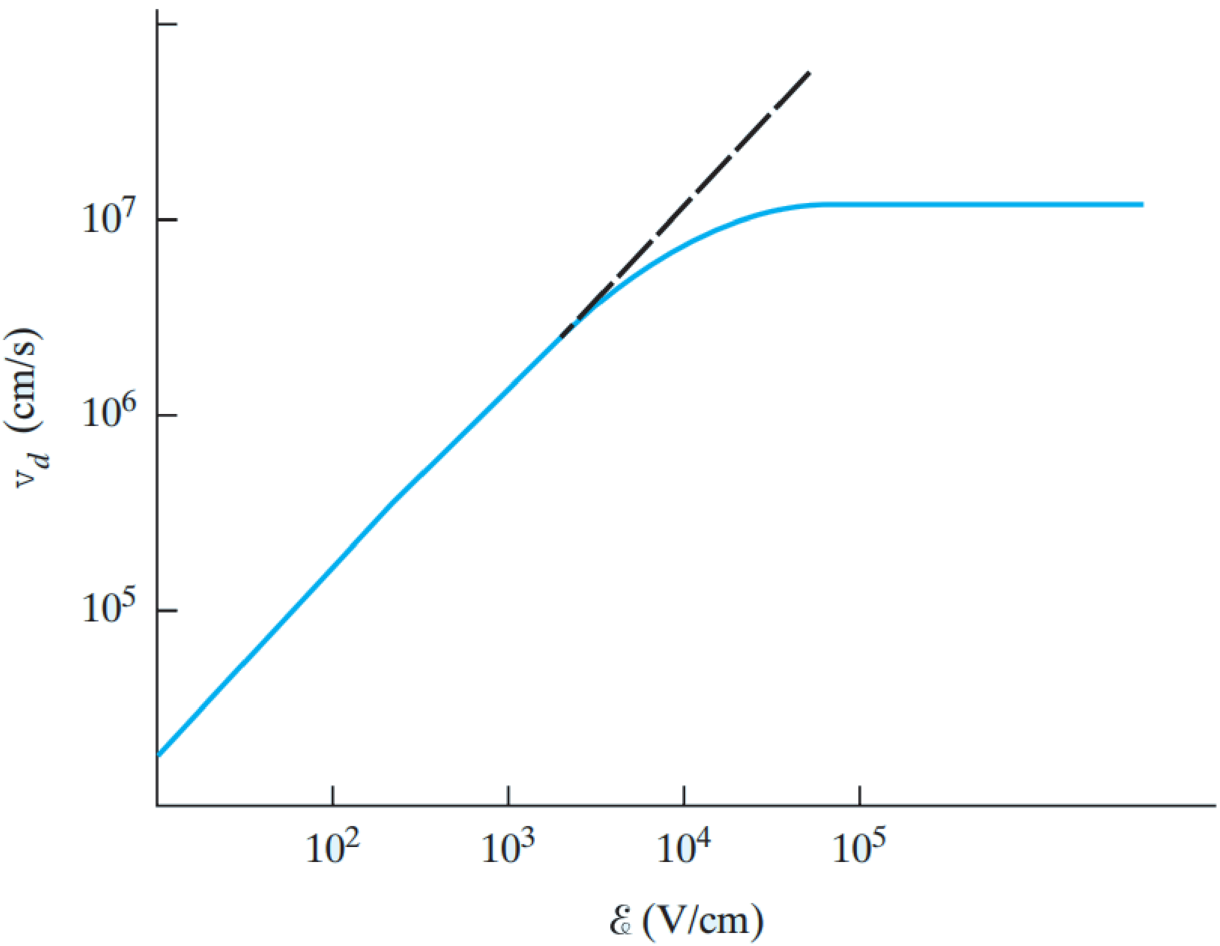


Figure 3–23
Variation of mobility with total doping impurity concentration ($N_a + N_d$) for Ge, Si, and GaAs at 300 K.

Figure 3–17
Intrinsic carrier concentration for Ge, Si, and GaAs as a function of inverse temperature. The room temperature values are marked for reference.





10^7
10^6
10^5
v_d (cm/s)
10^2
10^3
10^4
10^5
$\mathcal{E}$ (V/cm)