

Assignment 6.1

Q1:
(a)
$$N_c = 2 \left(\frac{2\pi m_e^* kT}{h^2} \right)^{3/2} = 2 \left[\frac{2\pi (0.56 \times 9.1 \times 10^{-31}) (1.38 \times 10^{-23}) 400}{(6.626 \times 10^{-34})^2} \right]^{3/2}$$

$$= 1.62 \times 10^{25} \text{ m}^{-3}$$

$$N_v = 2 \left(\frac{2\pi m_h^* kT}{h^2} \right)^{3/2} = 2 \left[\frac{2\pi (0.4 \times 9.1 \times 10^{-31}) (1.38 \times 10^{-23}) 400}{(6.626 \times 10^{-34})^2} \right]^{3/2}$$

$$= 9.75 \times 10^{24} \text{ m}^{-3}$$

$$n_i = (N_c N_v)^{1/2} \exp\left(-\frac{E_g}{2kT}\right) = [(1.62 \times 10^{25})(9.75 \times 10^{24})]^{1/2}$$

$$\cdot \exp\left(-\frac{0.66 \times 1.6 \times 10^{-19}}{2(1.38 \times 10^{-23}) 400}\right)$$

$$= 8.81 \times 10^{20} \text{ m}^{-3} = \underline{8.81 \times 10^{14} \text{ cm}^{-3}}$$

(b)
$$n_i = (N_c N_v)^{1/2} \exp\left(-\frac{E_g}{2kT}\right) = [(1.04 \times 10^{19})(6.0 \times 10^{18})]^{1/2}$$

$$\cdot \exp\left(-\frac{0.66 \times 1.6 \times 10^{-19}}{2(1.38 \times 10^{-23}) 300}\right)$$

$$= 2.28 \times 10^{19} \text{ m}^{-3} = \underline{2.28 \times 10^{13} \text{ cm}^{-3}}$$

(c)
$$\rho = \frac{1}{\sigma} = \frac{1}{en_i(\mu_h + \mu_e)} = \frac{1}{(1.6 \times 10^{-19})(2.28 \times 10^{13})(3900 + 1900)}$$

$$= \underline{46.85 \text{ } \Omega \text{ cm}}$$

Q2:
$$E_{Fi} = E_v + \frac{1}{2} E_g - \frac{3}{4} kT \ln\left(\frac{m_e^*}{m_h^*}\right)$$

$$= E_v + \frac{1}{2} E_g - \frac{3}{4} (8.62 \times 10^{-5} \text{ eV K}^{-1}) (300 \text{ K}) \ln\left(\frac{0.067 m_e}{0.5 m_e}\right)$$

$$= E_v + \frac{1}{2} E_g + \underline{0.039 \text{ eV}} \quad (\because \text{assumption of } E_{Fi} \text{ at middle of } E_g \text{ is valid!})$$

Q3:
$$\sigma = en\mu_e + ep\mu_h$$

$$\cong en\mu_e$$

$$= (1.6 \times 10^{-19} \text{ C})(10^{15} \text{ cm}^{-3})(1350 \text{ cm}^2 \text{ V}^{-1} \text{ s}^{-1})$$

$$= 0.216 \text{ } \Omega^{-1} \text{ cm}^{-1}$$

$$\rho = \frac{1}{\sigma} = \underline{4.63 \text{ } \Omega \text{ cm}}$$

Q4: $\sigma = \frac{1}{\rho} = 1 \Omega^{-1} \text{cm}^{-1}$

(a)

For p-type Si: $\sigma = en\mu_e + ep\mu_h = eN_a\mu_h$

$N_a = \frac{\sigma}{e\mu_h} = \frac{1}{1.6 \times 10^{-19} \times 450} = \underline{1.39 \times 10^{16} \text{cm}^{-3}}$

(b) $E_F - E_{Fi} = -kT \ln\left(\frac{N_a}{n_i}\right) = -(8.62 \times 10^{-5} \text{eV K}^{-1})(300 \text{K})$

$\cdot \ln\left[\frac{1.39 \times 10^{16} \text{cm}^{-3}}{10^{10} \text{cm}^{-3}}\right] = \underline{-0.37 \text{eV}}$

Q5: Energy band diagram

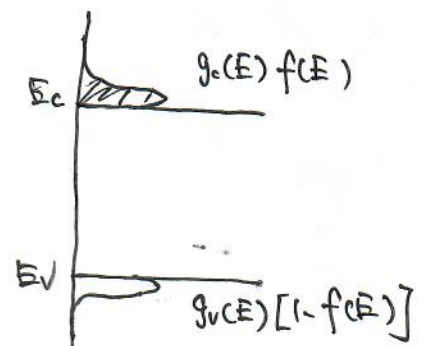
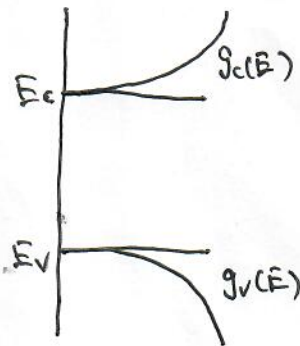
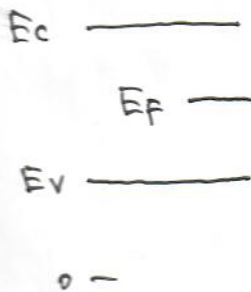
Density of states

Fermi-Dirac probability

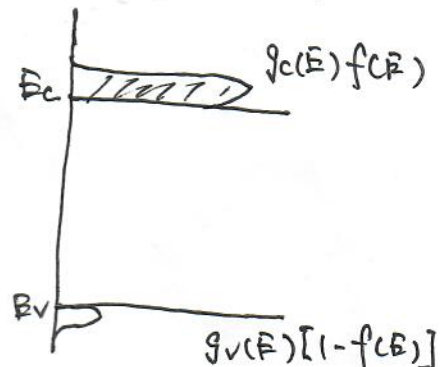
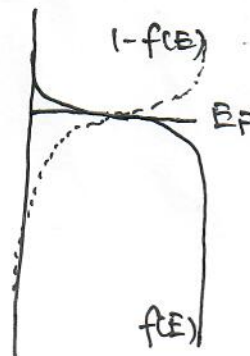
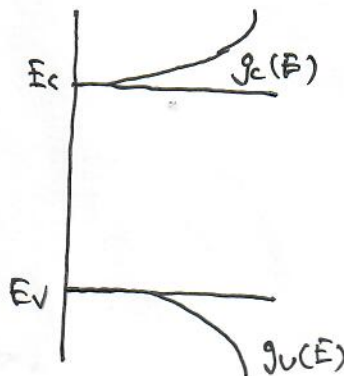
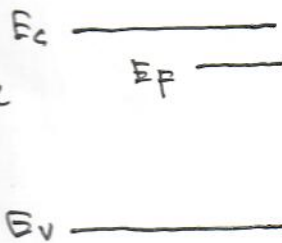
Carrier distribution

Vacuum

intrinsic



n-type



p-type

