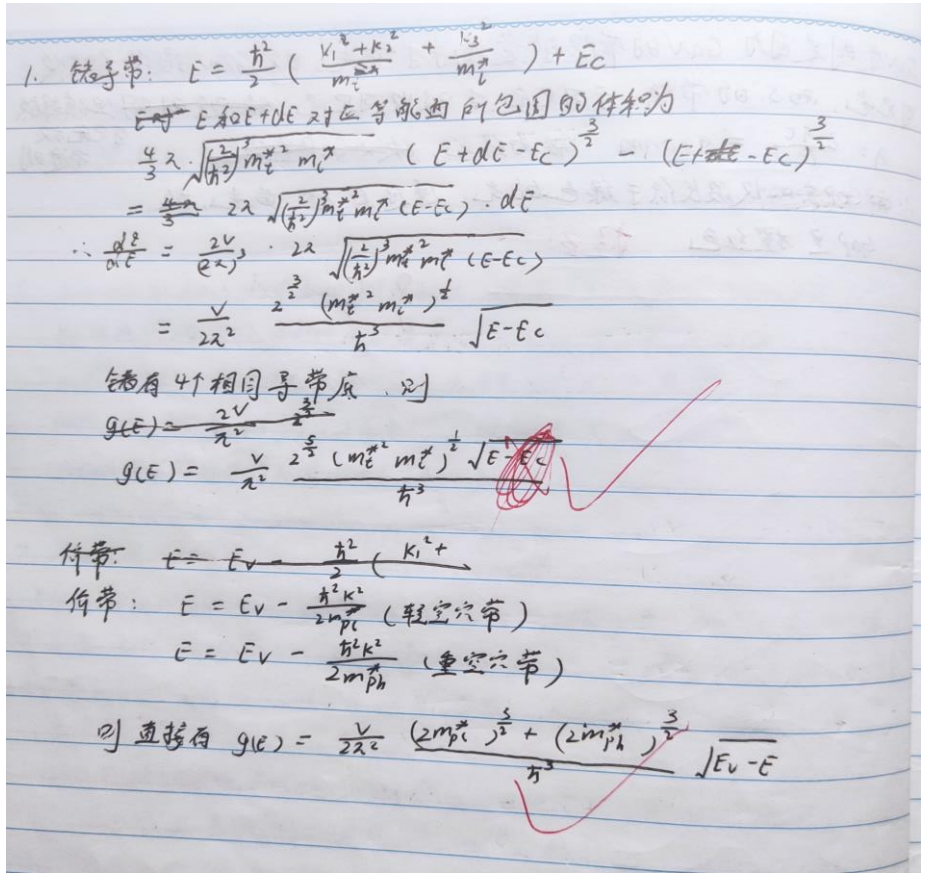

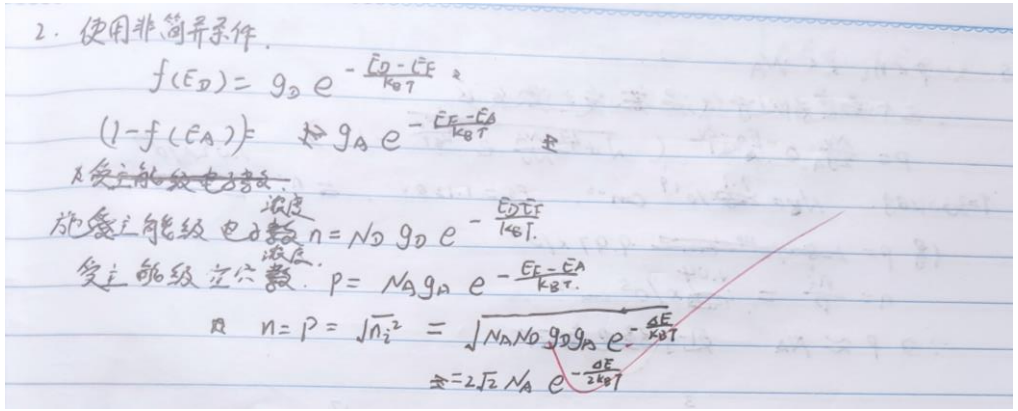

3. 300 K时kBT = 26 meV

nD=pA=5.6e-17,即补偿率为99.9…95%（总共16个9）

如果需要补偿率99%，即nD=pA=0.01，此时T~2085 K

说明通常情况下都能补偿

4. 设掺入磷的浓度为 N_D

$p = \frac{n_i^2}{n} = \frac{(1.7\times10^{13})^2}{10^{17}} \ll n$

∴ 处于低温杂质饱和激发区，掺杂浓度 $N_D > 10^{17}$

即 $\frac{4g_D N_D}{N_c} e^{\frac{E_c-E_D}{k_BT}} \gg 1$

~~∴ 处于强电离区，中间电离区。~~

~~$\therefore n = \left(\frac{N_c N_D}{g_D}\right)^{\frac{1}{2}} e^{-\frac{E_c-E_D}{2k_BT}} = 10^{17}$~~

~~得 $N_D =$~~

$\therefore n = \frac{N_c}{2g_D} e^{-\frac{E_c-E_D}{k_BT}} \left(\sqrt{1+\frac{4g_D N_D}{N_c} e^{\frac{E_c-E_D}{k_BT}}} - 1\right)$

得 $N_D = 1.03\times10^{17}\ cm^{-3}$

5. ∵ $p < n_i \ll N_A$

∴ 三个温度都处于低温激发本征激发区。

$p = \frac{N_V}{2g_A} e^{-\frac{E_A-E_V}{k_BT}} \left(\sqrt{1+\frac{4g_A N_A}{N_V} e^{\frac{E_A-E_V}{k_BT}}} - 1\right)$

$T=300K$ 时，$N_V = 1.1\times10^{19}\ cm^{-3}$，$E_g = 1.12\ eV$，$n_i = 1.02\times10^{10}\ cm^{-3}$

得 $p = 9.97\times10^{14}$

$n = \frac{n_i^2}{p} = 1.04\times10^{5}\ cm^{-3}$

∵ $p \approx N_A$ 处于强电离区。

$T=50K$ 时，$N_V = \left(\frac{50}{300}\right)^{\frac{3}{2}}\times1.1\times10^{19} = 7.48\times10^{17}\ cm^{-3}$

$n_i = \left(\frac{50}{300}\right)^{\frac{3}{2}} \cdot \frac{e^{-\frac{E_g}{2k_B\cdot50}}}{e^{-\frac{E_g}{2k_B\cdot300}}} \times1.02\times10^{10} \approx 0$

得 $p = 4.18\times10^{13}\ cm^{-3}$

$n = \frac{n_i^2}{p} = 0$

$\therefore \frac{4g_A N_A}{N_V} e^{\frac{E_A-E_V}{k_BT}} \gg 1$ 为弱电离区。

$T=350K$ 时，$n_i = \left(\frac{350}{300}\right)^{\frac{3}{2}} \cdot \frac{e^{-\frac{E_g}{2k_B\cdot350}}}{e^{-\frac{E_g}{2k_B\cdot300}}} \times1.02\times10^{10} \approx 2.58\times10^{14}\ cm^{-3}$

$N_V = \left(\frac{350}{300}\right)^{\frac{3}{2}}\times1.1\times10^{19} = 1.39\times10^{19}\ cm^{-3}$

得 $p = 9.99\times10^{14}\ cm^{-3} \approx 10^{15} = N_A$

处于强电离区

$n = \frac{n_i^2}{p} = 6.7\times10^{7}\ cm^{-3}$

8. 上正下负 则 载流子为空穴

$$n = \frac{JB}{Eq}$$

$$= \frac{\frac{I}{S}B}{\frac{U}{d}\cdot q}$$

$$= \frac{IB}{Uq}\cdot\frac{d}{S}$$

$$= \frac{1\times10^{-3}\times 2000\times10^{-4}}{1.6\times10^{-3}\cdot 1.6\times10^{-19}} \times \frac{1}{200\times10^{-6}}$$

$$= 3.9\times10^{21}\ m^{-3}$$

7. 本征半导体费米能级 $E_F = \frac{E_V+E_C}{2} - \frac{1}{2}k_BT\ln\frac{N_C}{N_V} = \frac{1}{2}(E_C+E_V)$ +0.037eV

~~P型~~ ∵ 在300K下, 对于GaAs 又小于强电离区

∴ P型 GaAs $E_F = E_V + k_BT\ln\frac{N_V}{N_A} = E_V + 0.17eV$

n型 GaAs $E_F = E_C - k_BT\ln\frac{N_C}{N_D} = E_C - 0.099eV$