3. Semiconductors

Problems

3.1. The semiconductor GaAs has the following parameters (all values at $T = 300\ \text{K}$):

$E_g = 1.42\ \text{eV}$ //bandgap

$m_\text{C}/m_0 = 0.067$ //electron effective mass

$m_\text{V}/m_0 = 0.48$ //hole effective mass

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a) Consider the undoped (intrinsic) material. Find:

i) N_C //conduction-band effective DOS

ii) N_V //valence-band effective DOS

iii) n_i //intrinsic carrier concentration

iv) $E_i - E_\text{V}$ //separation of the intrinsic level from the valence-band edge

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b) Assume the material is doped with $N_\text{D} = 4.0\times10^{16}\ \text{cm}^{-3}$ donors (e.g., S). The donor ionization energy is $V_n = 0.050\ \text{eV}$. The acceptor concentration is zero. Find

i) $E_\text{F} - E_\text{V}$ //separation of the Fermi level from the valence-band edge

ii) n //electron concentration

iii) p //hole concentration

iv) $N_\text{D}^{(+)}/N_\text{D}$ //fraction of ionized donors

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c) Assume the donor concentration is zero, but the material is doped with $N_\text{A} = 2.0\times10^{16}\ \text{cm}^{-3}$ acceptors (e.g., Zn). The acceptor ionization energy is $V_p = 0.080\ \text{eV}$. Find

i) $E_\text{F} - E_\text{V}$ //separation of the Fermi level from the valence-band edge

ii) n //electron concentration

iii) p //hole concentration

iv) $N_\text{A}^{(-)}/N_\text{A}$ //fraction of ionized acceptors

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d) Assume the donor concentration is $N_\text{A} = 2.0\times10^{16}\ \text{cm}^{-3}$ ($V_n = 0.050\ \text{eV}$) and the acceptor concentration is with $N_\text{A} = 2.0\times10^{16}\ \text{cm}^{-3}$ ($V_p = 0.080\ \text{eV}$). Find

i) $E_\text{F} - E_\text{V}$ //separation of the Fermi level from the valence-band edge

ii) n //electron concentration

iii) p //hole concentration

iv) $N_\text{D}^{(+)}/N_\text{D}$ //fraction of ionized donors

v) $N_\text{A}^{(-)}/N_\text{A}$ //fraction of ionized acceptors