4.10 Given the effective masses of electrons and holes in silicon, germanium, and gallium arsenide, calculate the position of the intrinsic Fermi energy level with respect to the center of the bandgap for each semiconductor at $T = 300$ K.

Per (4.266), $E_{Fi} - E_{midgap} = \frac{3}{4} k_B T \ln\left(\frac{m_p^*}{m_n^*}\right)$

Where $\frac{3}{4} k_B T = \frac{3}{4}(1.380649 \times 10^{-23}) 300 = 3.10646 \times 10^{-21}$ J

$= \frac{3}{4}(8.617333 \times 10^{-5}) 300 = 0.019389$ eV

Silicon Per Table B.4, $m_p^* = 0.56 m_0$ & $m_n^* = 1.08 m_0$

$E_{Fi} - E_{midgap} = 3.10646 \times 10^{-21} \ln\left(\frac{0.56 m_0}{1.08 m_0}\right)$

$= 0.019389 \ln\left(\frac{0.56}{1.08}\right)$

$E_{Fi} - E_{midgap} = -2.04026 \times 10^{-21}$ J $= -0.012734$ eV

Germanium Per Table B.4, $m_p^* = 0.37 m_0$ & $m_n^* = 0.55 m_0$

$E_{Fi} - E_{midgap} = 3.10646 \times 10^{-21} \ln\left(\frac{0.37 m_0}{0.55 m_0}\right)$

$= 0.019389 \ln\left(\frac{0.37}{0.55}\right)$

$E_{Fi} - E_{midgap} = -1.23145 \times 10^{-21}$ J $= -0.0076861$ eV

GaAs Per Table B.4, $m_p^* = 0.48 m_0$ & $m_n^* = 0.067 m_0$

$E_{Fi} - E_{midgap} = 3.10646 \times 10^{-21} \ln\left(\frac{0.48 m_0}{0.067 m_0}\right)$

$= 0.019389 \ln\left(\frac{0.48}{0.067}\right)$

$E_{Fi} - E_{midgap} = 6.11691 \times 10^{-21}$ J $= 0.038179$ eV