Sample Problem for Midterm 1

For Si at 300K, $N_D = 6.5 \times 10^{15}$ cm^{-3} and $N_A = 400$ cm^{-3}. Find $E_C - E_F$ in units of eV.

$N_C = (2.5 \times 10^{19}\ cm^{-3})(m_n^*/m_0^*)^{3/2}$
(Equation found on p.51 in textbook)
$m_n^*/m_0^* = 1.18$ for Si at 300K
$\Rightarrow N_C = 3.21 \times 10^{19}\ cm^{-3}$

$n = N_D = 6.5 \times 10^{15}\ cm^{-3}$ since $N >> n_o$ and $N_D >> N_A$

$n = N_C \exp(E_F - E_C)/kT$
$n/N_C = \exp(E_F - E_C)/kT$
$\ln(n/N_C) = (E_F - E_C)/kT$
$kT \ln(n/N_C) = E_F - E_C$
$E_C - E_F = -kT \ln(n/N_C)$
$= -(0.0259eV)\ln(6.5 \times 10^{15}\ cm^{-3} / 3.21 \times 10^{19}\ cm^{-3})$
$= 0.220eV$

Answer Check:
$E_G = 1.12eV$ for Si at 300K
If the system was intrinsic, $E_C - E_F = E_G/2 = 1.12eV/2 = 0.56eV$
If this is an n-type material, then E_F should be closer to E_C than E_V.
If this is a p-type material, then E_F should be closer to E_V than E_C.
So, since this is an n-type material, $E_C - E_F < E_G/2$
For our problem, $E_C - E_F = 0.220eV$ and $E_G/2 = 0.56eV$, so our answer makes sense.