

- 4.18 The value of  $p_0$  in silicon at  $T = 300$  K is  $2 \times 10^{16} \text{ cm}^{-3}$ . (a) Determine  $E_F - E_v$ .  
 (b) Calculate the value of  $E_c - E_F$ . (c) What is the value of  $n_0$ ? (d) Determine  $E_{Fi} - E_F$ .  
 ➤ First, find  $N_c$  and  $N_v$ .

Per Table 4.1,  $N_c = 2.8 \times 10^{19} \text{ #/cm}^3$       $m_n^* = 1.08 m_0$   
 $N_v = 1.04 \times 10^{19} \text{ #/cm}^3$       $m_p^* = 0.56 m_0$

Per (4.10),  $N_c = 2 \left[ \frac{2\pi m_n^* k_B T}{h^2} \right]^{3/2}$   
 $= 2 \left[ \frac{2\pi \cdot 1.08 (9.1093837 \times 10^{-31}) \cdot 1.380649 \times 10^{-23} \cdot 300}{(6.62607 \times 10^{-34})^2} \right]^{3/2}$

$N_c = 2.8165 \times 10^{25} \text{ #/m}^3 = 2.8165 \times 10^{19} \text{ #/cm}^3$

Per (4.18),  $N_v = 2 \left[ \frac{2\pi m_p^* k_B T}{h^2} \right]^{3/2} = N_c \left( \frac{0.56}{1.08} \right)^{3/2}$

$N_v = 1.0516 \times 10^{25} \text{ #/m}^3 = 1.0516 \times 10^{19} \text{ #/cm}^3$

a) (4.19)  $p_0 = N_v e^{-(E_F - E_v)/k_B T}$

↳  $E_F - E_v = k_B T \ln \left( \frac{N_v}{p_0} \right) = \underbrace{8.617333 \times 10^{-5} (300)}_{0.025852} \ln \left( \frac{1.0516 \times 10^{19}}{2 \times 10^{16}} \right)$

$E_F - E_v = 0.16196 \text{ eV}$

b)  $E_g = E_c - E_v = (E_c - E_F) + (E_F - E_v)$

↳  $E_c - E_F = E_g - (E_F - E_v) = 1.12 - 0.16196$

$E_c - E_F = 0.95804 \text{ eV}$

c) (4.11)  $n_0 = N_c e^{-(E_c - E_F)/k_B T} = 1.0516 \times 10^{25} e^{\frac{-0.95804}{0.025852}}$

$n_0 = 2.2665 \times 10^9 \text{ #/m}^3 = 2.2665 \times 10^3 \text{ #/cm}^3$