39. (a) The number of electrons in the valence band is

$$N_{\text{ev}} = N_v P(E_v) = \frac{N_v}{e^{(E_v - E_{\text{F}})/kT} + 1} \ .$$

Since there are a total of N_v states in the valence band, the number of holes in the valence band is

$$\begin{aligned} N_{\text{hv}} &= N_v - N_{\text{ev}} = N_v \left[1 - \frac{1}{e^{(E_v - E_{\text{F}})/kT} + 1}\right] \\ &= \frac{N_v}{e^{-(E_v - E_{\text{F}})/kT} + 1} \ . \end{aligned}$$

Now, the number of electrons in the conduction band is

$$N_{\text{ec}} = N_c P(E_c) = \frac{N_c}{e^{(E_c - E_{\text{F}})/kT} + 1} \ ,$$

Hence, from $N_{\text{ev}} = N_{\text{hc}}$, we get

$$\frac{N_v}{e^{-(E_v - E_{\text{F}})/kT} + 1} = \frac{N_c}{e^{(E_c - E_{\text{F}})/kT} + 1} \ .$$

(b) In this case, $e^{(E_c - E_{\text{F}})/kT} \gg 1$ and $e^{-(E_v - E_{\text{F}})/kT} \gg 1$. Thus, from the result of part (a),

$$\frac{N_c}{e^{(E_c - E_{\text{F}})/kT}} \approx \frac{N_v}{e^{-(E_v - E_{\text{F}})/kT}} \ ,$$

or $e^{(E_v - E_c + 2E_{\text{F}})/kT} \approx N_v/N_c$. We solve for E_{F}:

$$E_{\text{F}} \approx \frac{1}{2}(E_c + E_v) + \frac{1}{2}kT \ln\left(\frac{N_v}{N_c}\right) \ .$$