**5.33** In silicon, the electron concentration is given by $n(x) = 10^{15} e^{-x/L_n}$ cm$^{-3}$ for $x \geq 0$ and the hole concentration is given by $p(x) = 5 \times 10^{15} e^{+x/L_p}$ cm$^{-3}$ for $x \leq 0$. The parameter values are $L_n = 2 \times 10^{-3}$ cm and $L_P = 5 \times 10^{-4}$ cm. The electron and hole diffusion coefficients are $D_n = 25$ cm$^2$/s and $D_P = 10$ cm$^2$/s, respectively. The total current density is defined as the sum of the electron and hole diffusion current densities at $x = 0$. Calculate the total current density.

Per (5.33), $J_{nx|dif} = eD_n \dfrac{dn}{dx}$. Using the given $n(x)$, we get

$$J_{nx|dif} = eD_n \frac{d}{dx}\left[10^{15} e^{-x/L_n}\right]$$

$$= eD_n 10^{15} \frac{-1}{L_n} e^{-x/L_n}$$

$$= \frac{-1.602176634\times10^{-19}(25)10^{15}}{2\times10^{-3}} e^{-x/2\times10^{-3}}$$

$$= -2.0027208\, e^{-x/2\times10^{-3}} \quad (\text{A/cm}^2)$$

Per (5.34), $J_{px|dif} = -eD_p \dfrac{dp}{dx}$. Using the given $p(x)$, we get

$$J_{px|dif} = -eD_p \frac{d}{dx}\left[5\times10^{15} e^{x/L_p}\right]$$

$$= -eD_p 5\times10^{15} \frac{1}{L_p} e^{x/L_p}$$

$$= \frac{-1.602176634\times10^{-19}(10)\,5\times10^{15}}{5\times10^{-4}} e^{x/L_p}$$

$$= -16.021766\, e^{x/5\times10^{-4}} \quad (\text{A/cm}^2)$$

At $x = 0$, $J_{\text{total}} = J_{nx|dif} + J_{px|dif}$ = -2.0027208 - 16.021766

$$\Rightarrow \quad \underline{\mathbf{J_{total} = -18.0245\ A/cm^2}}.$$