SOLUTION P-5 FALL 2014

a) Holes are the minority carriers:

Steady state:

$$D \frac{d^2 \Delta p}{dx^2} - \frac{\Delta p}{\tau} + \alpha I e^{-\alpha x} = 0$$

homog. eq.: $$D \frac{d^2 \Delta p}{dx^2} - \frac{\Delta p}{\tau} = 0$$

$$\Delta p_h(x) = \Delta p_1 e^{-x/L} + \Delta p_2 e^{x/L}$$

$$L = \sqrt{D\tau}$$

partic. sol. to inhomog. eq. : $\Delta p_p(x) = \Delta p_3 e^{-\alpha x}$

$$\frac{d^2 \Delta p_p}{dx^2} = \alpha^2 \Delta p_3 e^{-\alpha x}$$

$$\rightarrow \quad D\alpha^2 \Delta p_3 e^{-\alpha x} - \frac{1}{\tau} \Delta p_3 e^{-\alpha x} = -\alpha I e^{-\alpha x}$$

$$\rightarrow \quad \Delta p_3 = \frac{-\alpha I}{D\alpha^2 - \frac{1}{\tau}} = \frac{\alpha I}{\frac{1}{\tau} - D\alpha^2}$$

if: $\alpha < \frac{1}{\sqrt{D\tau}} \rightarrow D\alpha^2 < \frac{1}{\tau} \rightarrow \Delta p_3 > 0$

Boundary cond's: $x \rightarrow \infty \quad \Delta p(x) \rightarrow 0$

$$\Rightarrow \Delta p_2 = 0$$

$$\rightarrow \quad \Delta p(x) = \Delta p_1 e^{-x/L} + \Delta p_3 e^{-\alpha x}$$

at $x = 0$: $$D \left.\frac{d\Delta p}{dx}\right|_0 = V_s \Delta p|_0$$

$$-\frac{\Delta p_1}{L} D - \Delta p_3 \alpha D = V_s (\Delta p_1 + \Delta p_3)$$

$$-\Delta p_1 \left(\frac{D}{L} + V_s\right) = V_s \Delta p_3 + \alpha D \Delta p_3$$

$$\Delta p_1 = - \frac{V_s + \alpha D}{V_s + D/L} \Delta p_3$$

$$\Rightarrow \quad \Delta p(x) = \frac{\alpha I}{\frac{1}{\tau} - \alpha^2 D} \left(e^{-\alpha x} - \frac{V_s + \alpha D}{V_s + D/L} e^{-x/L} \right)$$

b) Because the semiconductor is not in a circuit there cannot be a current flowing anywhere in steady state.
All hole currents are exactly cancelled (locally) by electron currents.