The Si $p^+\text{-}n$ step-junction diode pictured below with a cross-sectional area $A$ and maintained at room temperature has the following special properties:

1. $W_N << L_P$, where $W_N$ is the total width of the $n$-region and $L_P$ is the hole diffusion length in the quasineutral $n$-region.
2. For all biases of interest, $x_n$, the $n$-side depletion width, is less than $W_N$.
3. $\Delta p_n = 0$ at $x = W_N$.

![Diode Diagram]

**Part A**

Complete the following steps to obtain an $I-V_A$ expression for the diffusion current (the ideal diode current) expected from the diode.

(10%) (a) Given special property #1, write down the simplest form of the minority carrier diffusion equation that must be solved to obtain $\Delta p_n(x)$ in the quasineutral $n$-region.

(10%) (b) What is the general solution to the part (a) equation?

(10%) (c) Write down the boundary conditions that must be applied to determine the specific $\Delta p_n(x)$ solution for the problem at hand.

(30%) (d) Invoking appropriate simplifications, complete the derivation of the diffusion current (the ideal-diode current) expected from the diode.

**Part B**

The diode pictured above is subsequently illuminated such that $G_L$ electron-hole pairs/cm$^3$-sec are generated uniformly throughout the diode.

(15%) (a) Derive an expression for the additional current, $I_{La}$, flowing in the diode because of photogeneration in the depletion region.

(25%) (b) Derive an expression for the additional current, $I_{Lh}$, flowing in the diode because of photogeneration in the quasineutral n-region. NOTE: Photogeneration in the quasineutral $n$-region perturbs the minority carrier distribution in the region.