Problem #1
The doping profiles for 2 ideal silicon long-base p-n junction diodes maintained at 300k are pictured below.

The minority carrier lifetimes in the quasi-neutral regions (\(\tau_n\), \(\tau_p\)) are the same for these 2 diodes.

Answer the following questions (circle the correct choice):

a) The magnitude of the built-in potential in Diode A is LARGER THAN the magnitude of the built-in potential in Diode B.

b) The saturation current of Diode A is SMALLER THAN the saturation current of Diode B.

c) The reverse breakdown voltage of Diode A is SMALLER THAN the reverse breakdown voltage of Diode B.

d) The minority carrier diffusion length on the n-type side is SMALLER in Diode A as compared with Diode B.

e) For a given forward bias (\(V_a > 0\)), the excess hole density at the edge of the depletion region on the n-type side, \(p_n(x_n)\), will be SMALLER in Diode A as compared with Diode B.

Problem #2
Consider a silicon sample maintained at 300K under equilibrium conditions, doped with the following impurities:

Phosphorus: $1 \times 10^{16}$ cm$^{-3}$  
Boron: $2 \times 10^{16}$ cm$^{-3}$

a) $p = Na-Nd = 10^{16}$ cm$^{-3}$  
$n = n_i^2/p = (1.45 \times 10^{10})^2/10^{16} = 2.1 \times 10^4$ cm$^{-3}$

Electron concentration: $2.1 \times 10^4$ cm$^{-3}$  
Hole Concentration: $10^{16}$ cm$^{-3}$

b) $Na + Nd = 3 \times 10^{16}$ cm$^{-3}$  
$\mu_n = 1000$ cm$^2$/V . S (From figure on page 2)  
$\mu_n = q\tau_{cn}/m_n^* \Rightarrow \tau_{cn} = \mu_n(m_n^*)/q = 0.148$ ps  
$l = (\tau_{cn})v_{th} = 1.48 \times 10^{-6}$ cm

Mean free path: $1.48 \times 10^{-6}$ cm = 14.8 nm

c) $\mu_p = 400$ cm$^2$/V . s  
$\rho = (q(\mu_n)n + q(\mu_p)p)^{-1} \approx (q(\mu_p)p)^{-1} = 1.56$ Omega - cm

d) 

**Problem #3**
a) far away from junction $p_n(x \to \infty)$: $G_L(tau_p)$

b) since $p_n(\infty)$ is finite and equal to $G_L(tau_p)$, $A2 = 0$, and $A3 = G_L(tau_p)$

\[
p_n(x_n) = A1 + G_L(tau_p) = \left(\frac{ni^2}{Nd}\right)(e^{qVa/kt} - 1)
\]

\[
p_n(x) = \left[\frac{\left(\frac{ni^2}{Nd}\right)(e^{qVa/kt} - 1) - G_L(tau_p)}{Lp}\right]e^{-\left(x-x_n\right)/Lp} + G_L(tau_p)
\]

c) Since this is a one-sided junction,

current density $J = Jn + Jp \approx Jp = -qDp(dp/dx)$

\[
I = -qAni^2(Dp/LpNd)(e^{qVa/kT} - 1) - qA(DpG_L(tau_p)/Lp + DnG_L(tau_n)/Ln)
\]

Note: The photogeneration on the p+ side will create excess minority carriers on that side also; these will contribute additional negative current $(-qA(dn/dn)G_L(tau_n))$.

**Problem #4**

No other solutions available