ECE 113A
Professor Burke (15400) Section A
Homework #5 Solutions and Grading Criteria

A voltage V_A of 0.4144V is being applied to a step junction with n and p side dopings of $N_A = 10^{15}$ cm^{-3} and $N_D = 10^{15}$ cm^{-3}, respectively. $n_i = 10^{10}cm^{-3}$.

Under equilibrium conditions:

$p_{p,o} = N_A = 10^{15}cm^{-3}$
$n_{p,o} = n_i^2/N_A = 10^5cm^{-3}$
$n_{n,o} = N_D = 10^{15}cm^{-3}$
$p_{n,o} = n_i^2/N_D = 10^5cm^{-3}$

For depletion region boundaries:

$\Delta n_p(-x_p) = (n_i^2/N_A)(exp[qV_A/kT] - 1)$
$= (10^5cm^{-3})(exp[0.4144V/0.259V] – 1)$
$= 8.92x10^{11}$ cm^{-3}
$\Delta p_n(x_n) = (n_i^2/N_D)(exp[qV_A/kT] - 1)$
$= (10^5cm^{-3})(exp[0.4144V/0.259V] – 1)$
$= 8.92x10^{11}$ cm^{-3}
$n_p = n_{p,o} + \Delta n_p(-x_p)\ exp[-x''/L_N]$
$p_n = p_{n,o} + \Delta p_n(x_n)\ exp[-x'/L_P]$

1) Calculate p on the p side at the interface. **(6 pts)**
   Since $\Delta n_p(-x_p) << p_{p,o}$, low-level injection prevails. Therefore, the majority carrier concentration is approximately unchanged.
   $p_p = p_{p,o} = 10^{15}cm^{-3}$ *(exact answer required or no credit)*
2) Calculate p on the p side 10 diffusion lengths away from the interface. **(6 pts)**
   $p_p = p_{p,o} = 10^{15}cm^{-3}$ *(exact answer required or no credit)*
3) Calculate p on the p side 20 diffusion lengths away from the interface. **(6 pts)**
   $p_p = p_{p,o} = 10^{15}cm^{-3}$ *(exact answer required or no credit)*
4) Calculate p on the p side 30 diffusion lengths away from the interface. **(6 pts)**
   $p_p = p_{p,o} = 10^{15}cm^{-3}$ *(exact answer required or no credit)*
5) Calculate n on the p side at the interface. **(6 pts)**
   $n_p = n_{p,o} + \Delta n_p(-x_p)\ exp[0]$
   $= 10^5cm^{-3} + 8.92x10^{11}$ cm^{-3}
   $= 8.92x10^{11}$ cm^{-3} *($8\text{-}10 \times 10^{11}$ cm^{-3} for credit)*
6) Calculate n on the p side 10 diffusion lengths away from the interface. **(6 pts)**
   $n_p = n_{p,o} + \Delta n_p(-x_p)\ exp[-10]$
   $= 10^5cm^{-3} + 8.92x10^{11}$ cm^{-3} $exp[-10]$
   $= 4.06x10^7$ cm^{-3} *($3\text{-}5 \times 10^7$ cm^{-3} for credit)*
7) Calculate n on the p side 20 diffusion lengths away from the interface. **(6 pts)**
   $n_p = n_{p,o} + \Delta n_p(-x_p)\ exp[-20]$
   $= 10^5cm^{-3} + 8.92x10^{11}$ cm^{-3} $exp[-20]$
   $= 1.02x10^5$ cm^{-3} *($0.8\text{-}1.2 \times 10^5$ cm^{-3} for credit)*
8) Calculate n on the p side 30 diffusion lengths away from the interface. **(6 pts)**
   $n_p = n_{p,o} + \Delta n_p(-x_p)\ exp[-30]$

$= 10^5 cm^{-3} + 8.92x10^{11}\ cm^{-3}\ exp[-30]$
$= 10^5\ cm^{-3}$ *(exact answer required or no credit)*

9) Calculate p on the n side at the interface. **(6 pts)**

$p_n = p_{n,o} + \Delta p_n(x_n)\ exp[0]$
$= 10^5 cm^{-3} + 8.92x10^{11}\ cm^{-3}$
$= 8.92x10^{11}\ cm^{-3}$ *(8-10 x $10^{11}\ cm^{-3}$ for credit)*

10) Calculate p on the n side 10 diffusion lengths away from the interface. **(6 pts)**

$p_n = p_{n,o} + \Delta p_n(x_n)\ exp[-10]$
$= 10^5 cm^{-3} + 8.92x10^{11}\ cm^{-3}\ exp[-10]$
$= 4.06x10^7\ cm^{-3}$ *(3-5 x $10^7\ cm^{-3}$ for credit)*

11) Calculate p on the n side 20 diffusion lengths away from the interface. **(6 pts)**

$p_n = p_{n,o} + \Delta p_n(x_n)\ exp[-20]$
$= 10^5 cm^{-3} + 8.92x10^{11}\ cm^{-3}\ exp[-20]$
$= 1.02x10^5\ cm^{-3}$ *(0.8-1.2 x $10^5\ cm^{-3}$ for credit)*

12) Calculate p on the n side 30 diffusion lengths away from the interface. **(6 pts)**

$p_n = p_{n,o} + \Delta p_n(x_n)\ exp[-30]$
$= 10^5 cm^{-3} + 8.92x10^{11}\ cm^{-3}\ exp[-30]$
$= 10^5\ cm^{-3}$ *(exact answer required or no credit)*

13) Calculate n on the n side at the interface. **(6 pts)**

Since $\Delta p_n(x_n) << n_{n,o}$, low-level injection prevails. Therefore, the majority carrier concentration is approximately unchanged.

$n_n = n_{n,o} = 10^{15} cm^{-3}$ *(exact answer required or no credit)*

14) Calculate n on the n side 10 diffusion lengths away from the interface. **(6 pts)**

$n_n = n_{n,o} = 10^{15} cm^{-3}$ *(exact answer required or no credit)*

15) Calculate n on the n side 20 diffusion lengths away from the interface. **(6 pts)**

$n_n = n_{n,o} = 10^{15} cm^{-3}$ *(exact answer required or no credit)*

16) Calculate n on the n side 30 diffusion lengths away from the interface. **(6 pts)**

$n_n = n_{n,o} = 10^{15} cm^{-3}$ *(exact answer required or no credit)*

17) Make a dimensioned log(p or n) versus x sketch of both the majority and minority carrier concentrations in the quasineutral regions of the device **(4 pts)**

(If any answer in #1-16 are wrong, no points for this section. No partial credit.)