1) $p_n(x)$? L'équation de continuité est comme suit :

$$\frac{\partial p_n}{\partial t} = D_p\left(\frac{\partial^2 p_n(x)}{\partial x^2}\right) - \mu_p \frac{\partial (p_n(x))E}{\partial x} + G_L - \frac{(p_n(x) - p_{n0})}{\tau_p}$$ (0,5)

$E = 0$, $G_L = 0$, $\frac{\partial p_n}{\partial t} = 0 \Rightarrow D_p \frac{\partial^2 p_n(x)}{\partial x^2} - \frac{(p_n(x) - p_{n0})}{\tau_p} = 0$ (0,25)

(0,25) (0,25) (0,25)

$$\frac{\partial^2 p_n(x)}{\partial x^2} - \frac{(p_n(x) - p_{n0})}{D_p \cdot \tau_p} = 0$$ (0,25)

$L_p^2 = D_p \tau_p$ (0,25) $\Rightarrow \frac{\partial^2 p_n(x)}{\partial x^2} - \frac{(p_n(x) - p_{n0})}{L_p^2} = 0$

La solution de cette équation différentielle (0,25) est :

$$p_n(x) - p_{n0} = A.e^{-x/L_p} + B.e^{x/L_p}$$ (0,5)

Les conditions aux limites sont :

$p_n(x_n) = p_{n0}.e^{V_a/U_T}$ (0,25) ; $p_n(W_n) = p_{n0}$ (0,25) (0,5)

$$p_n(x_n) - p_{n0} = A.e^{-x_n/L_p} + B.e^{x_n/L_p} = p_{n0}(e^{V_a/U_T} - 1)$$ (0,5)

$$p_n(W_n) - p_{n0} = A.e^{-W_n/L_p} + B.e^{W_n/L_p} = 0$$ (0,5) (0,5)

$$\begin{cases} A.e^{-x_n/L_p} + B.e^{x_n/L_p} = p_{n0}(e^{V_a/U_T} - 1) \\ A.e^{-W_n/L_p} + B.e^{W_n/L_p} = 0 \end{cases}$$

$$\Delta = \begin{vmatrix} e^{-x_n/L_p} & e^{x_n/L_p} \\ e^{-W_n/L_p} & e^{W_n/L_p} \end{vmatrix} = 2\,sh\left(\frac{W_n - x_n}{L_p}\right)$$ (1) (0,5)

$$A = \begin{vmatrix} p_{n0}(e^{V_a/U_T} - 1) & e^{x_n/L_p} \\ 0 & e^{W_n/L_p} \end{vmatrix} / 2sh\left(\frac{W_n - x_n}{L_p}\right) = \frac{\left(p_{n0}\,e^{W_n/L_p}(e^{V_a/U_T} - 1)\right)}{2sh\left(\frac{W_n - x_n}{L_p}\right)}$$ (1) (0,5)

$$B = \begin{vmatrix} e^{-W_n/L_p} & p_{n0}(e^{V_a/U_T} - 1) \\ e^{-x_n/L_p} & 0 \end{vmatrix} / 2sh\left(\frac{W_n - x_n}{L_p}\right) = \frac{\left(-p_{n0}.e^{-W_n/L_p}(e^{V_a/U_T} - 1)\right)}{2sh\left(\frac{W_n - x_n}{L_p}\right)}$$ (1) (0,5)

$$p_n(x) - p_{n0} = \left(\left(e^{W_n/L_p - x/L_p} - e^{-W_n/L_p \cdot x/L_p}\right) p_{n0}.(e^{V_a/U_T} - 1)\right) / 2sh\left(\frac{W_n - x_n}{L_p}\right)$$

$$p_n(x) - p_{n0} = p_{n0}.\left(e^{V_a/U_T} - 1\right)\left(\frac{sh\left(\frac{(W_n - x)}{L_p}\right)}{sh\left(\frac{W_n - x_n}{L_p}\right)}\right)$$ (1) .... (1)

par analogie : $n_p(x) - n_{p_0} = n_{p_0}\left(e^{Va/u_T} - 1\right)\left(\frac{sh\left(\frac{W_p + x}{L_n}\right)}{sh\left(\frac{W_p - x_p}{L_n}\right)}\right)$ ....(2) 1

2) $J_{np}(x) = q D_n \frac{\partial n_p(x)}{\partial x}$; 0,25

$J_{pn}(x) = -q D_p \frac{\partial p_n(x)}{\partial x}$ 0,25

$J_{np}(x) = \left(\frac{q D_n n_{p_0} ch\left(\frac{W_p + x}{L_n}\right)}{L_n \; sh\left(\frac{W_p - x_p}{L_n}\right)}\right)\left(e^{Va/u_T} - 1\right)$ 0,5

$J_{pn}(x) = \left(\frac{q D_p p_{n_0} ch\left(\frac{W_n - x}{L_p}\right)}{L_p \; sh\left(\frac{W_n - x_n}{L_p}\right)}\right)\left(e^{Va/u_T} - 1\right)$ 0,5

3) $J_n(-x_p) = J_n(x_n)$; 0,25 $J_p(x_n) = J_p(-x_p)$ 0,25 $\Rightarrow J_T = J_n(-x_p) + J_p(-x_p)$ 0,25
$= J_n(x_n) + J_p(x_n) \Rightarrow J_T = J_n(-x_p) + J_p(x_n)$ 0,25 $= J_{sat}\left(e^{Va/u_T} - 1\right)$. 0,25

$J_{sat} = \left(\frac{q D_n n_i^2}{N_A L_n \, sh\left(\frac{W_p - x_p}{L_n}\right)} + \frac{q D_p n_i^2}{N_D L_p \, sh\left(\frac{W_n - x_n}{L_p}\right)}\right)$ 0,75

4) Jonction courte ; $(W_p - x_p) \ll L_n$ et $(W_n - x_n) \ll L_p$ 0,5
Dans les équations (1) et (2) $sh\theta \simeq \theta$. 0,25

$p_n(x) = p_{n_0} + p_{n_0}\frac{(W_n - x)}{(W_n - x_n)}\left(e^{Va/u_T} - 1\right)$ 0,25 et $n_p(x) = n_{p_0} + n_{p_0}\left(\frac{W_p + x}{W_p - x_p}\right)\left(e^{Va/u_T} - 1\right)$ 0,25

$J_{pn}(x) = \left(\frac{p_{n_0} \cdot q D_p}{(W_n - x_n)}\right)\left(e^{Va/u_T} - 1\right)$ 0,75 et $J_{np}(x) = \left(\frac{n_{p_0} \cdot q \cdot D_n}{N_A (W_p - x_p)}\right)\left(e^{Va/u_T} - 1\right)$ 0,75

$J_{sat} = \left(\frac{q n_i^2 D_n}{N_A (W_p - x_p)} + \frac{q n_i^2 D_p}{N_D (W_n - x_n)}\right)$ 0,75

5) Jonction P^+N courte ; $N_A \gg N_D$ 0,25 ; $J_{sat} = \frac{q n_i^2 D_p}{N_D (W_n - x_n)}$ 0,5

$J_{sat} = \frac{(1,6 \cdot 10^{-19})(10^{20})(10)}{(2 \cdot 10^{15})(1 - 0,25)10^{-4}}$ 0,25 $= \frac{1,6 \, 10^{2}}{2 (0,75) 10^{11}} = 1,06 \, 10^{-9} = 1 \cdot 10^{-9} A/cm^2$

$J_{sat} = 10^{-9} A/cm^2$

0,25