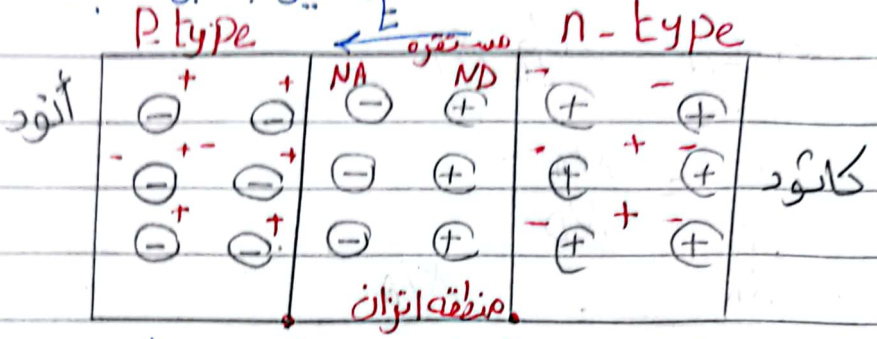
PAGE DATE Lec 3 Anod ○ ▷ ○ Cathod

أتزان $I_{total} = 0$

∴ the junction becomes at equiliprium

يوجد بها مجال كهربي ← E



منطقة خالية من الالكترونات الحرة ← x_p x_n depeletion rejon

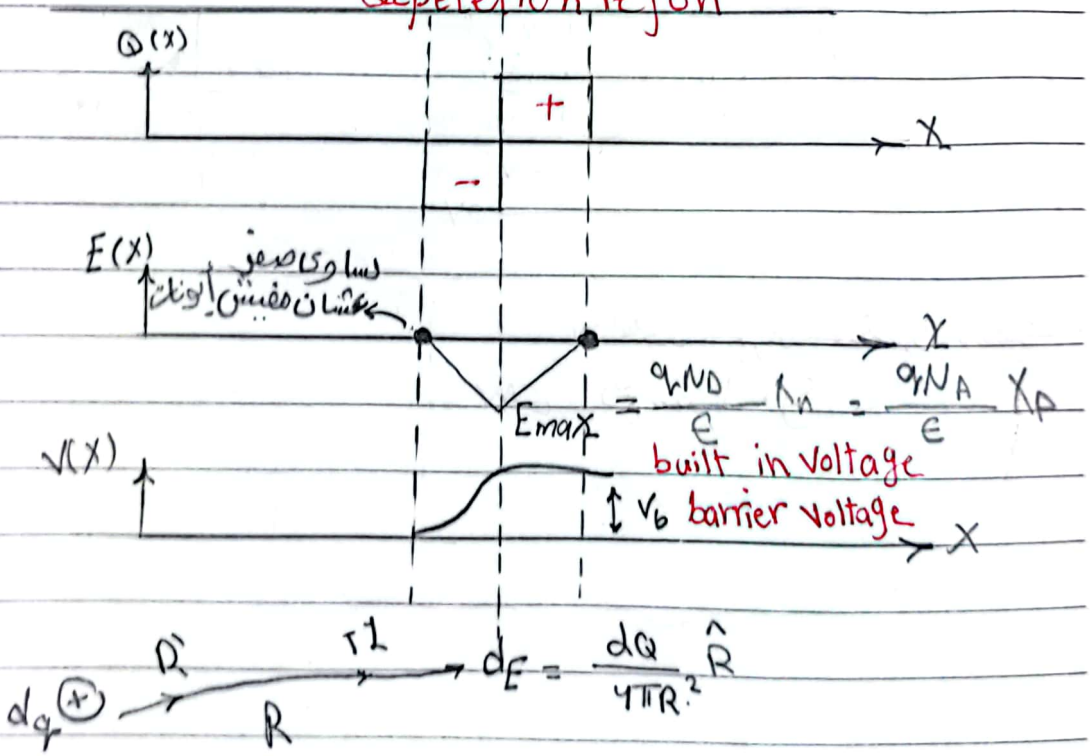
$$I_n = q n \mu_n E + q D_n \frac{dn}{dx}$$

$$I_p = q p \mu_p E - q \frac{dp}{dx}$$

$W = x_n + x_p$ draw E(x), V(x), Q(x) for pn junction

مما ينشأ المجال الكهربي ← تقابل الايونات ⊕ مع الالكترونات ⊖

depeletion rejon



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In the depletion region

$$Q_+ = Q_-$$

$$qN_D A x_n = qN_A A x_p$$

$$N_D x_n = N_A x_p$$

$$\frac{x_n}{x_p} = \frac{N_A}{N_D}$$

$$\frac{x_n}{x_n + x_p} = \frac{N_A}{N_A + N_D}$$

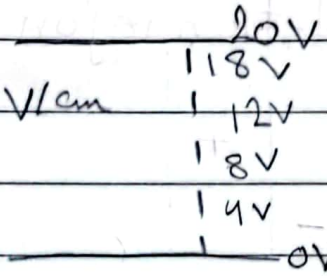
$$x_n = W \frac{N_A}{N_A + N_D}$$

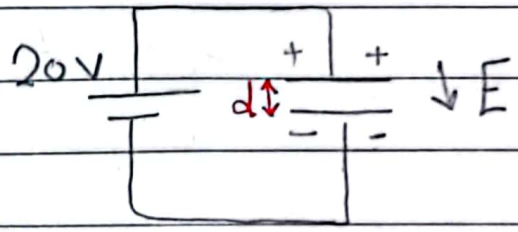
$$x_p = W \frac{N_D}{N_A + N_D}$$

$Q_+ = qN_D A x_n$

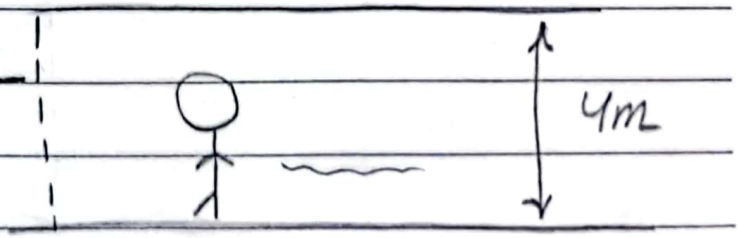
$Q_- = qN_A A x_p$

$$E = \frac{20}{5} = 4\ V/cm$$





* المجال الكهربي ← خطوط وهمية
كهربية لا ترى



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$X_n \Rightarrow$ n-type المنطقة $X_p \Rightarrow$ P-type المنطقة

Ex: Calculate the bilt in voltage in a Silicon Pn junction at $T = 300k$ For the following

(i) $N_a = 5*10^{15}/cm^3$, $N_D = 10^{17}/cm^3$

(ii) $N_a = 2*10^{16}/cm^3$, $N_D = 2*10^{15}/cm^3$

Sol:

$$V_b = \frac{KT}{q} \ln \frac{N_A N_D}{n_i^2}$$

V_b ... built in voltage

K ... Boltzman constant $1.38*10^{-23}\ J/K$

N_A ... concentration of acceptor atoms

N_D ... " " Donor "

q ... Charge of electrons $1.6*10^{19}\ C$

n ... Concentration of intrinsic silicon.

$$V_t = \frac{KT}{q} = \frac{1.38*10^{-23}\ J/K \cdot 300\ K}{1.6*10^{-19}\ C} \quad \text{amp·volt·sec / amp·sec}$$

$$= 0,026V = 26\ mV$$

$$n_i = 1.5*10^{10}/cm$$

i) $V_b = 0.026 * \ln\left(\frac{5*10^{15}*10^{17}}{(1.5*10^{10})^2}\right) = 0,736\ V$

ii) $V_b = 0,026 \ln\left(\frac{2*10^{16}*2*10^{15}}{(1.5*10^{10})^2}\right) = 0.69\ V$

$\Rightarrow$ bilt in voltage depends on: T, N_A, N_D

$$E_{max} = \frac{q N_D}{\epsilon} x_n \qquad W = \sqrt{\frac{2\epsilon}{q}\left[\frac{1}{N_A} + \frac{1}{N_D}\right] V_b}$$

$$x_n N_D = x_p N_A$$

$$\frac{x_n}{x_p} = \frac{N_A}{N_D} \qquad \frac{x_n}{W} = \frac{N_A}{N_A + N_D} \qquad x_n = W \frac{N_A}{N_A + N_D}$$

$$W = \sqrt{\frac{2*1.04*10^{-12}}{1.6*10^{-19}}\left[\frac{1}{5*10^{15}} + \frac{1}{10^{17}}\right] * 0.736} \qquad E_{max} = \frac{1.6*10^{-19}*10^{17}(x_n)}{1.04*10^{-12}} = \text{Volt/cm}$$

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