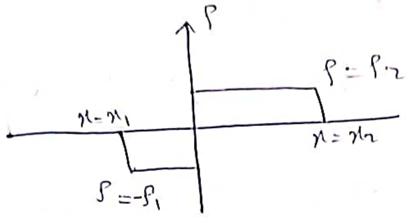
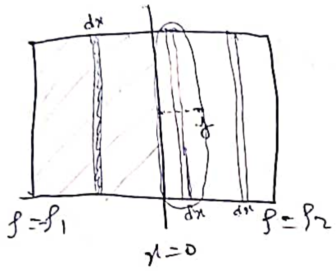
Field and Potential in p-n junction :-

ρ (Charge density) as a function of x





$\sigma = -\rho_1 dx$

$dE_1 = \dfrac{-\rho_1 dx}{2\epsilon}$

$\epsilon = \epsilon_0 K$ ↳ dielectric constant (12 for Silicon)

$\therefore E_1 = -\dfrac{\rho_1}{2\epsilon}\int dx$

$= -\dfrac{\rho_1 x_1}{2\epsilon}$

$dE_2 = \dfrac{\rho_2 dx}{2\epsilon}$

$$\boxed{E_2 = \frac{\rho_2 y}{2\epsilon}}$$

$dE_3 = \dfrac{-\rho_2 dx}{2\epsilon}$

$E_3 = -\dfrac{\rho_2(x_2 - y)}{2\epsilon}$

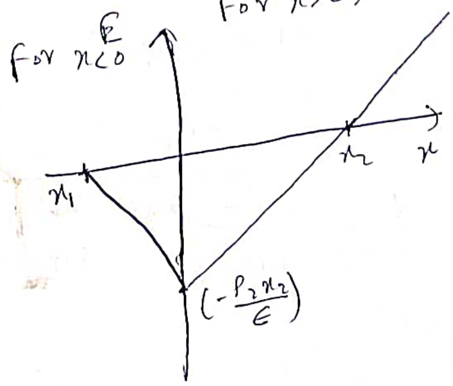
$\rho_1 x_1 = \rho_2 x_2$

$E_1 + E_2 + E_3 = -\dfrac{\rho_1 x_1}{2\epsilon} + \dfrac{\rho_2 y}{2\epsilon} - \dfrac{\rho_2(x_2 - y)}{2\epsilon}$

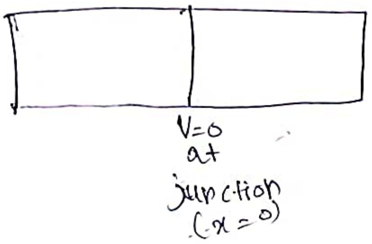
$= \dfrac{\rho_2 y}{\epsilon} - \dfrac{(\rho_1 x_1 + \rho_2 x_2)}{2\epsilon}$

$= \dfrac{\rho_2 y}{\epsilon} - \dfrac{\rho_2 x_2}{\epsilon}$

$= \dfrac{\rho_2 (y - x_2)}{\epsilon} = \dfrac{\rho_2}{\epsilon}(x - x_2)$ → Distance from junction.



∴ Electric field is linear in the depletion region



$$dV = -\mathcal{E}\,dx$$

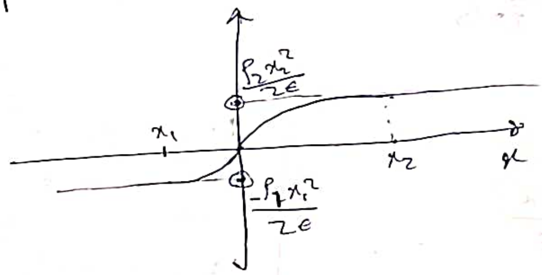
$$V = \int -\frac{\rho_2}{\epsilon}(x - x_2)\,dx$$

$$= -\frac{\rho_2}{\epsilon}\frac{(x-x_2)^2}{2} + c$$

$$0 = -\frac{\rho_2}{\epsilon}x_2^2 + c$$

$$\therefore V = -\frac{\rho_2}{2\epsilon}\left[(x-x_2)^2 - x_2^2\right]$$

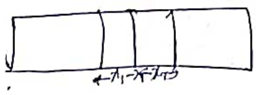
Graph for potential



$$V = \frac{\rho_1 x_1^2 + \rho_2 x_2^2}{2\epsilon}$$

Conduction-band, Valence band energies (Barrier)

Barrier height $V_0 = \frac{\rho_1 x_1^2}{2\epsilon} + \frac{\rho_2 x_2^2}{2\epsilon} = \frac{1}{2\epsilon}(\rho_1 x_1^2 + \rho_2 x_2^2)$



$$X = x_1 + x_2$$

$$\rho_1 x_1 = \rho_2 x_2$$

$$x_2 = \frac{X\rho_1}{\rho_1 + \rho_2}$$

$$\therefore V_0 = \frac{1}{2\epsilon}\rho_2 x_2 X$$

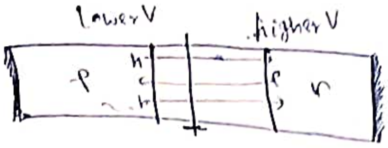
$$V_0 = \frac{1}{2\epsilon} \times \frac{\rho_1 \rho_2 X^2}{\rho_1 + \rho_2}$$

$$\rho_1 = eN_A$$

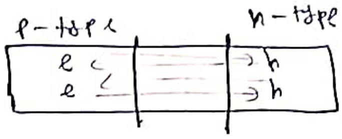
$$\rho_2 = eN_B$$

$$X = \sqrt{\frac{2\epsilon V_0}{e}\left(\frac{1}{N_A} + \frac{1}{N_B}\right)}$$

* potential barrier ↑ Depletion layer thicker and vice versa.
* For high doping, depletion layer will be small



I diffusion :- Majority carrier try to diffuse on the other side because of concentration gradient and facing the opposition of this depletion layer electric field still some are able to cross and that creates Diffusion current from p to n.



minority carriers

Drift currents from n to p direction.

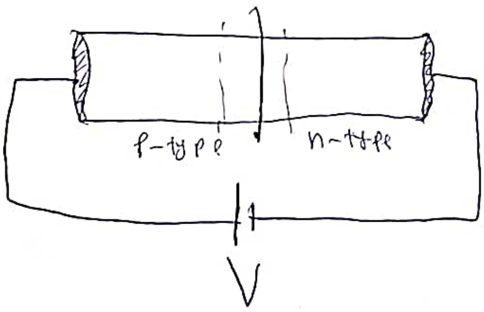
↳ * depends & determined by concentration of minority carriers.

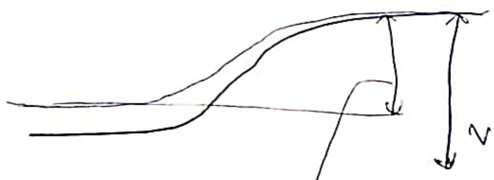
In equilibrium

$I_{diffusion} = I_{drift}$

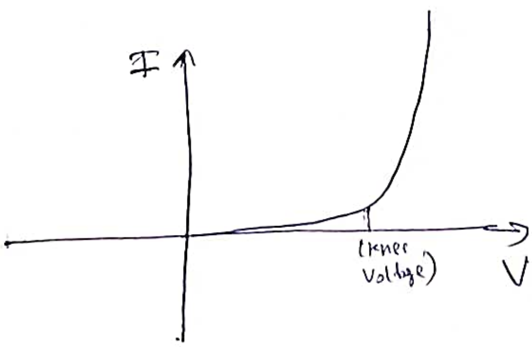
Net current is zero.

Biasing :-





forward biasing.



* Barrier height is reduced this is known as forward biasing
* Width of depletion layer decreases
* Diffusion current will increase
* Drift current remains same
* Net current will increase.