Donors / acceptors:

Equilibrium :

typically all ionized, wide range of T

(density not too big)

Donors: pull μ toward CB edge.

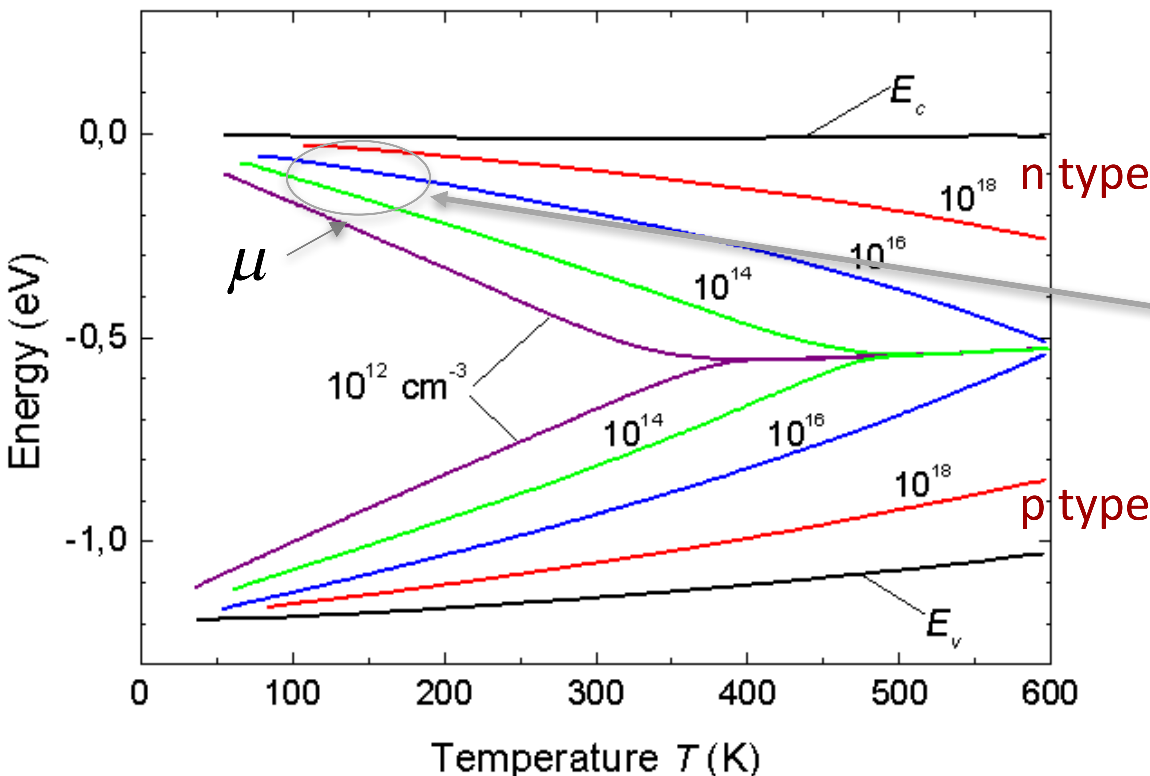
prob. of ionized donor

$$n - p = N_d \left[1 - \frac{1}{1 + \frac{1}{2} e^{(\varepsilon_d - \mu)/kT}} \right]$$

$$n \approx N_c(T) e^{-(\varepsilon_c - \mu)/kT}$$

$$p \approx P_v(T) e^{-(\mu - \varepsilon_v)/kT}$$

Solve for μ.



www.ioffe.ru

Example suppose:

$\varepsilon_c - \varepsilon_d = k_B \times$ (room temperature)

$N_c = 10^{19}[T/\mathrm{RT}]^{3/2}$

$N_D = 10^{15}$ (in cm^{-3})

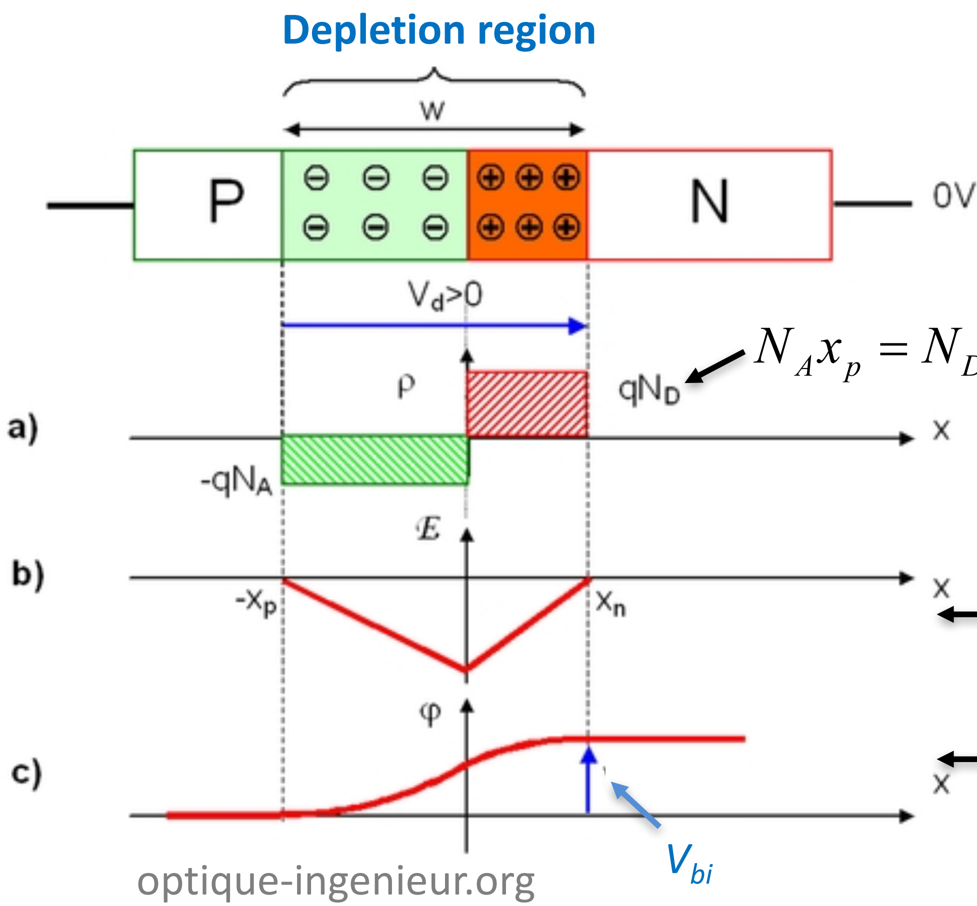
$N_c = 1.9 \times 10^{18}$

Then if $T = \mathrm{RT}/3 \simeq 100$ K,

Solve → $n = 0.98 \times N_D = 9.8 \times 10^{14}$

$\varepsilon_c - \mu = 7.58 \times (k_B T) \simeq 0.063$ eV

Semiconductor p-n junctions:



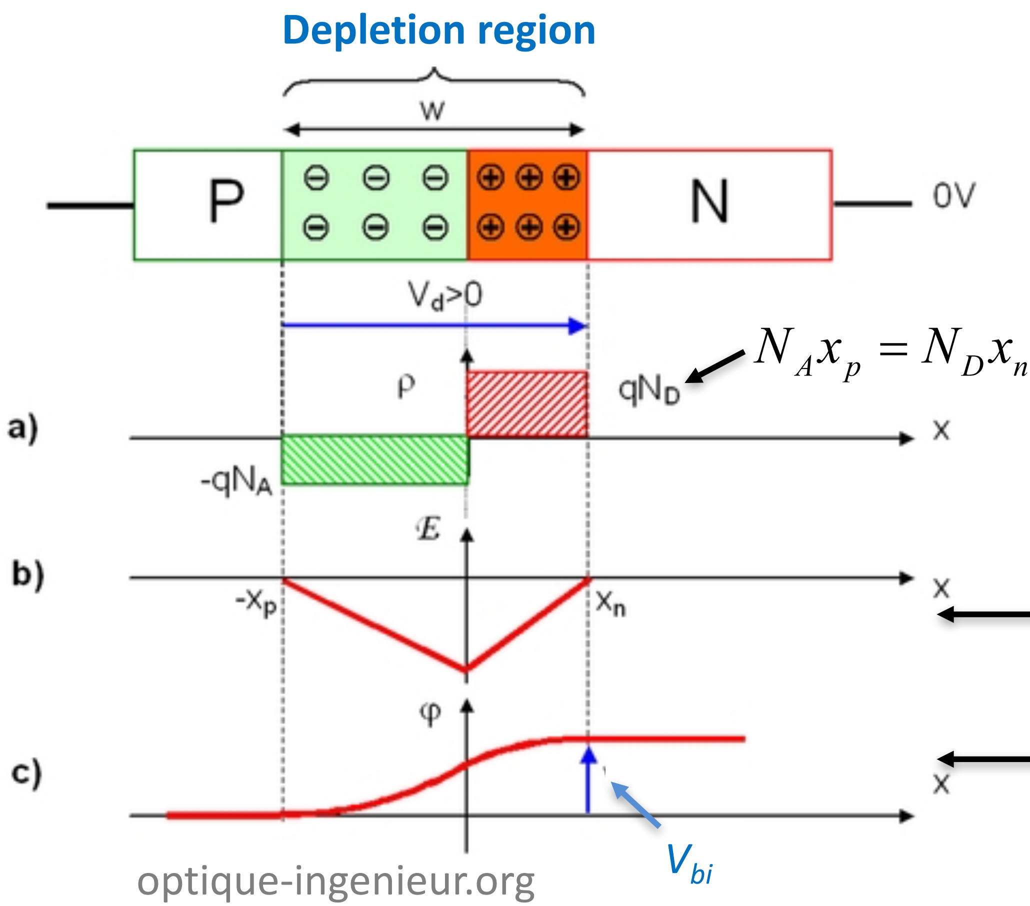
$N_A x_p = N_D x_n$

- Depletion region: high resistivity
- Width *W* determined by donor/acceptor density
- "Built in voltage" V_{bi} set by chemical potentials in *p* & *n* regions (eV_{bi} close to ε_g).

$$E_{p,n} = E_o \pm 4\pi N_{A,D} e x / \kappa$$

$$\Delta V_p = \frac{2\pi N_A e x_p^2}{\kappa} \quad \Delta V_n = \frac{2\pi N_D e x_n^2}{\kappa}$$

Semiconductor p-n junctions:



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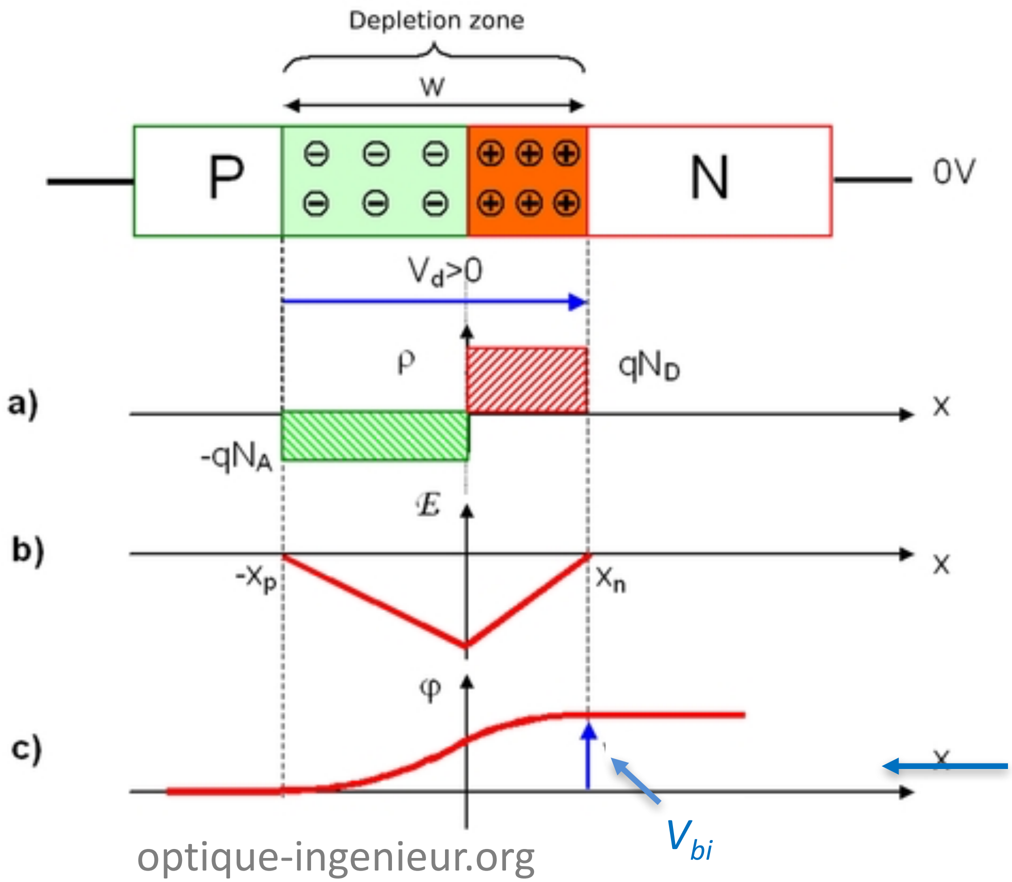
$$x_n = \sqrt{\frac{\kappa V_{bi} N_A}{2\pi N_D e (N_A + N_D)}}$$

Typical, $W \approx 1\ \mu\text{m}$

(Si, $N_A = N_D = 10^{15}$ cm^{-3})

Semiconductor p-n junctions:



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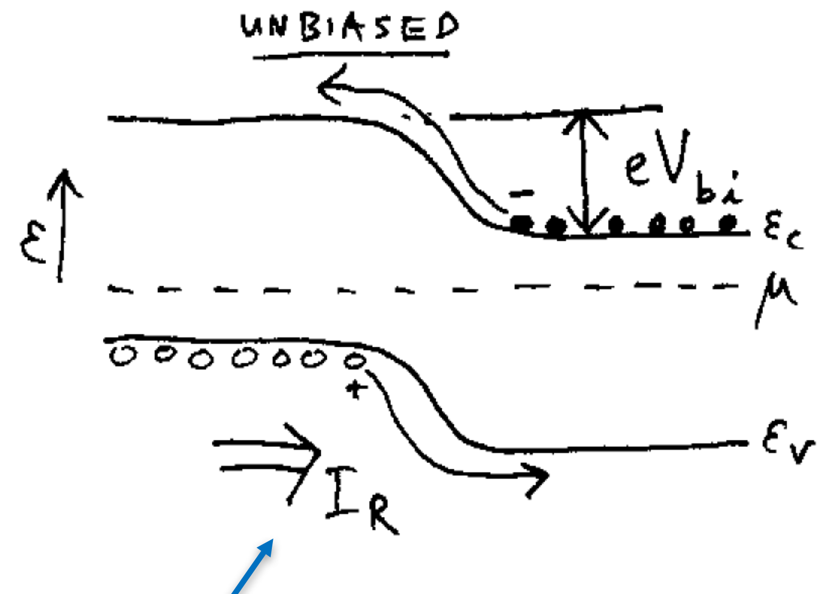
Bands scale according to local electric potential:



$$U_{\text{electrons}} = -eV_{\text{internal}}$$

Note, chemical potential is what is measured externally

(e.g. with ideal voltmeter)

Also note, we assumed here *V* varies slowly.

(OK if donor densities not too large)