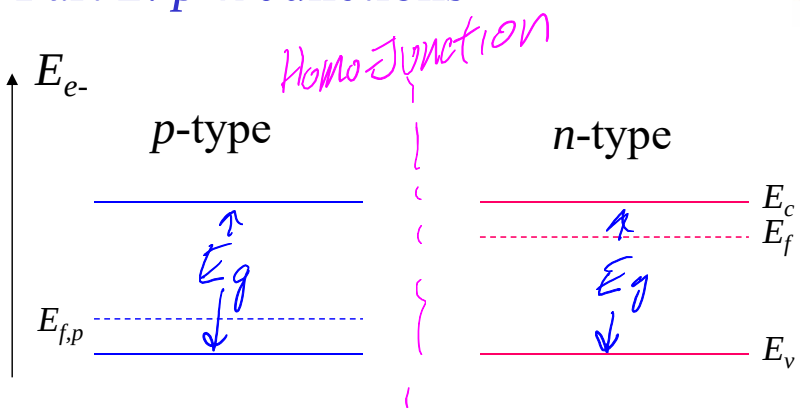
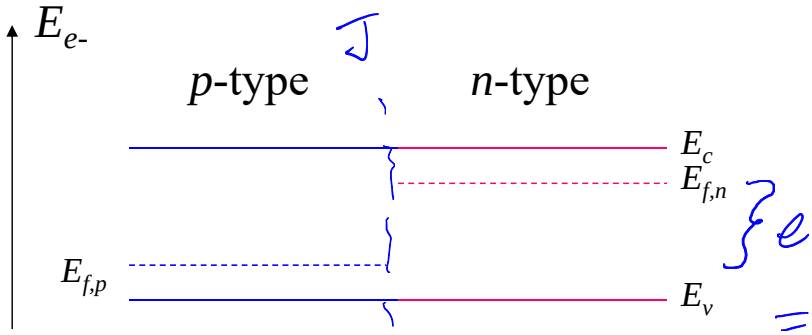
Part 2: *p*-*n* Junctions

Flat band



Flat band



p-n Junctions

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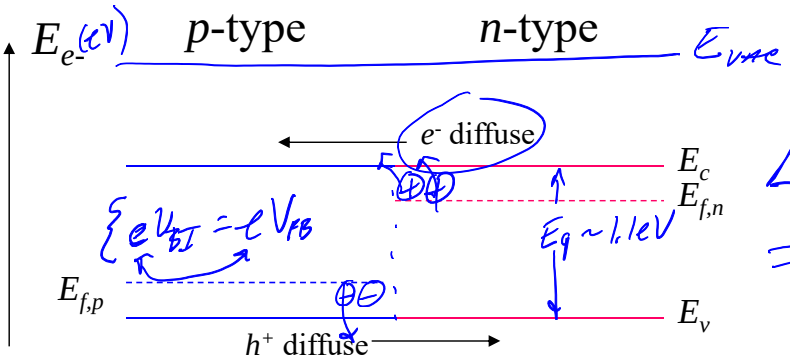
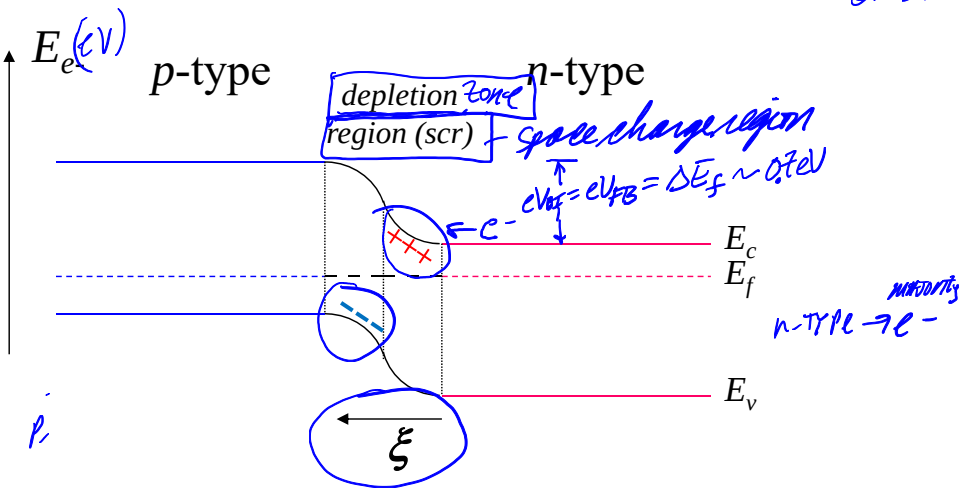
1ST **Flat band**



$\Delta E_f = \Delta \mu$

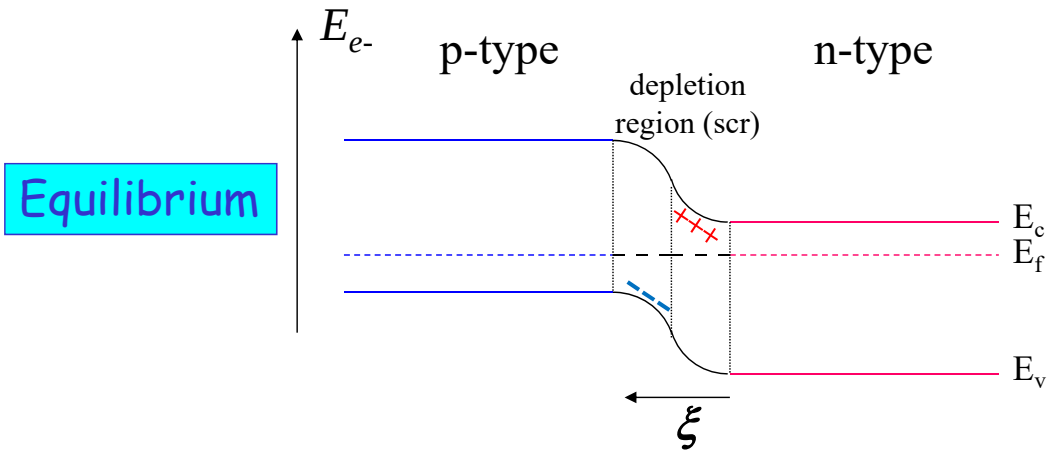
$\Rightarrow$ Driving force for diffusion

2ND **Equilibrium**



n-type → e⁻ majority

p-n Junctions



$$\rho = q\left[\left(p + N_D^+\right) - \left(n + N_A^-\right)\right]$$

$$-\frac{d\xi}{dx} = -\frac{\rho}{\varepsilon}$$

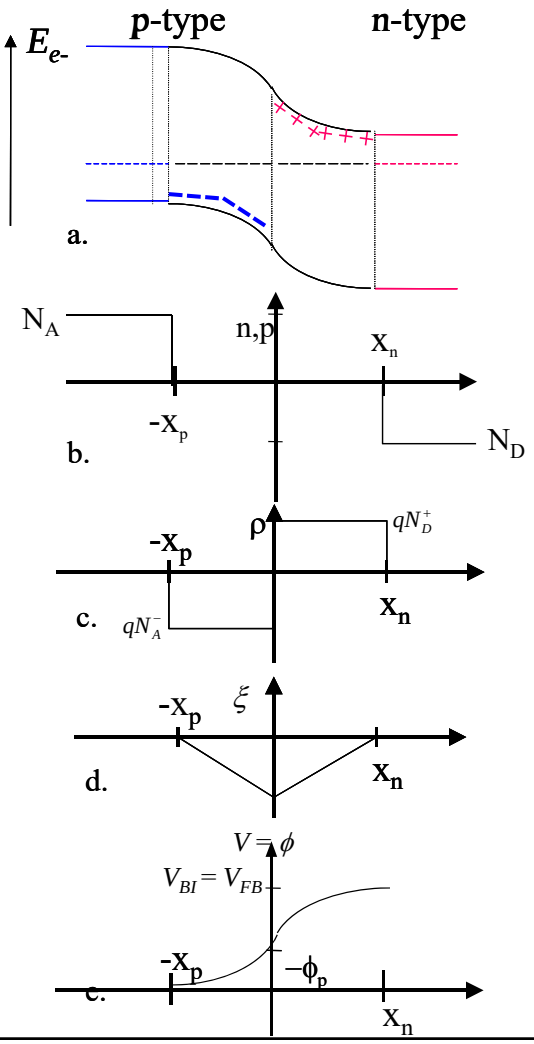
where

$$\varepsilon = \varepsilon_o \varepsilon_R$$

$$\frac{d^2V}{dx^2} = -\frac{d\xi}{dx} = -\frac{\rho}{\varepsilon}$$

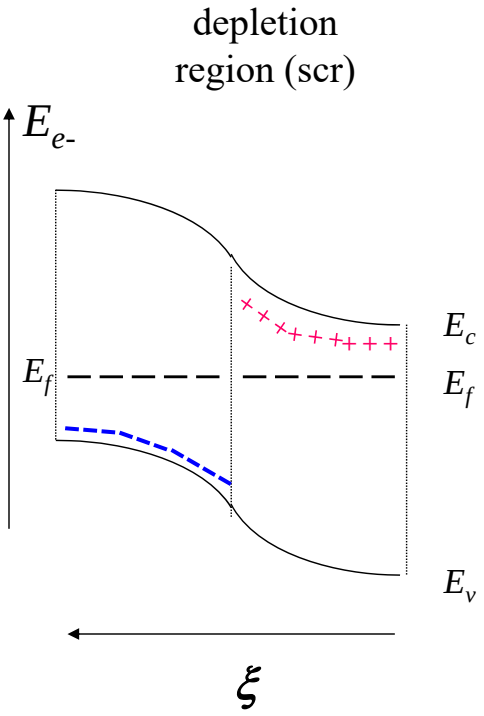
Poisson's Equation

p-n Junctions



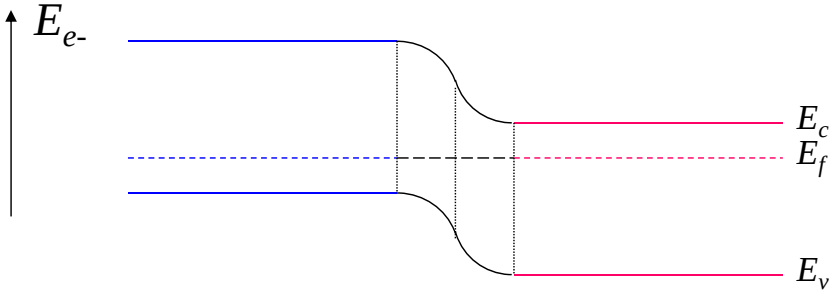
p-n Junctions

- Current Flow in *p-n* junction:
  - ✓ 1st: *diffusion* of e^-'s & h^+'s occur due to the difference in E_f (μ_{chem}).
    - o *Current density* due to diffusion: J_{dif}
  - ✓ 2nd: *Electric field* is induced due to *ionized donors* and *ionized acceptors*.
  - ✓ 3rd: Electric field induces e^-'s & h^+'s to *drift*.
    - o *Current density* due to drift: J_{drift}



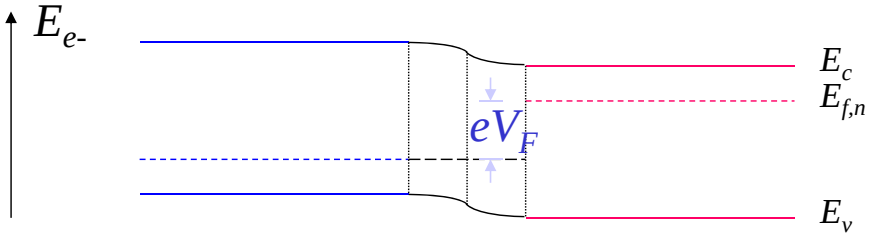
Steady State: $J_{dif} = -J_{drift}$ OR $J_{dif} + J_{drift} = 0$

p-n Junctions

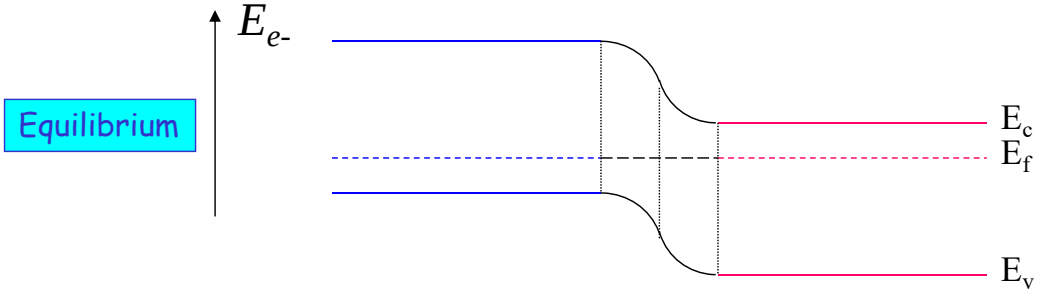


Question: If a forward bias is applied to the junction, what bias do we put on the:
- *n*-type side?
- *p*-type side?

Question: How will the E_f respond on the:
- *n*-type side?
- *p*-type side?

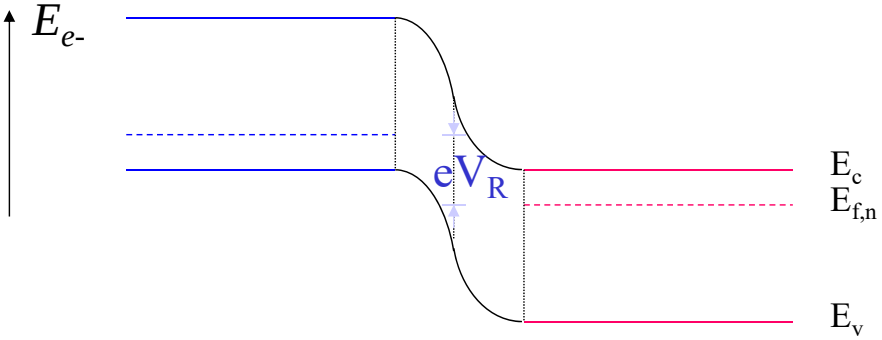


p-n Junctions



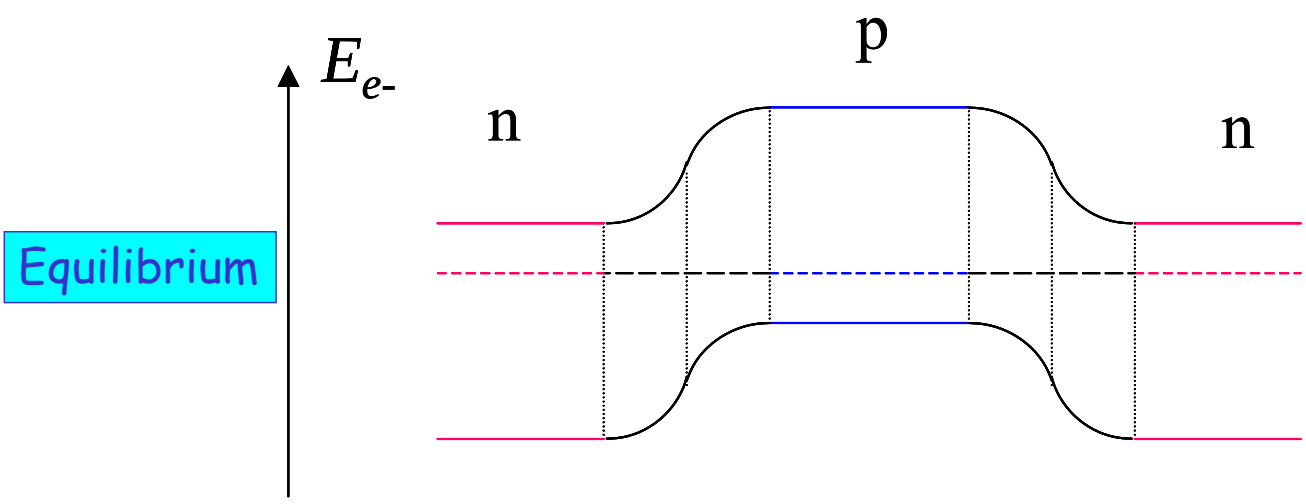
Question: If a *reverse* bias is applied to the junction, what bias do we put on the:
- n-type side?
- p-type side?

Question: How will the E_f respond on the:
- n-type side?
- p-type side?



How can a p-n junction be used as a diode?

n-p-n Junctions



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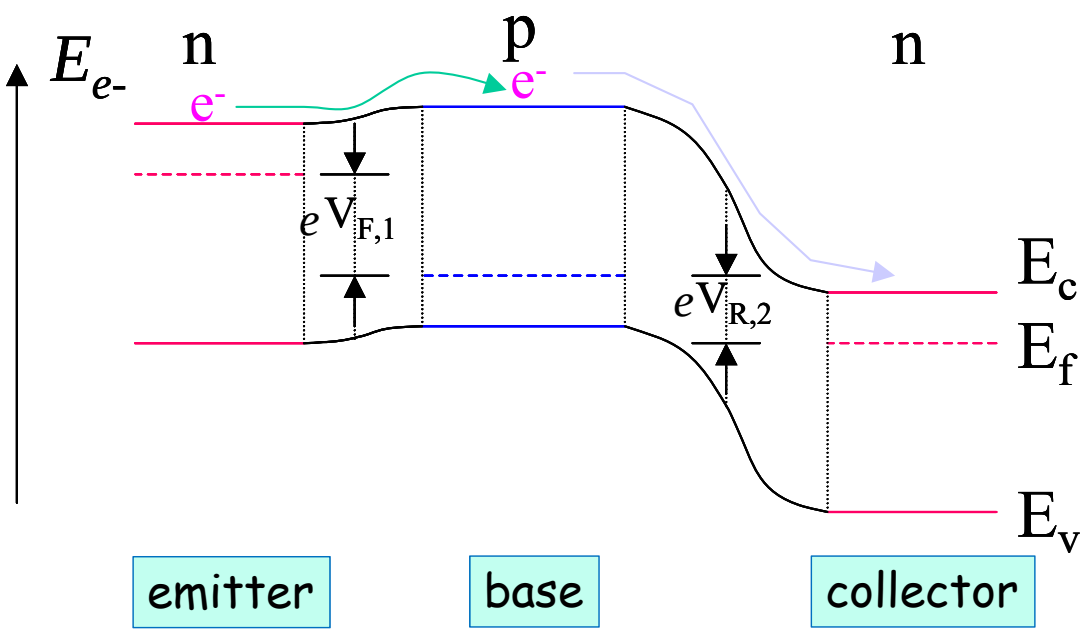
Bipolar Transistor Action



Ralph Brown comments on W. Shockley's Book

- Ralph Brown – *Director of Research at Bell Labs*
  - ✓ Introducing Dr. William Shockley's book "*Electron & Holes in Semiconductors*"
  - ✓ Dr. William Shockley – awarded the Nobel Prize in Physics for the semiconductor amplifier (transistor) in 1956 with Dr. John Bardeen & Dr. Walter Brattain

"*…example of how research directed at basic understanding of materials and their behavior, "pure" research if you will, sooner for later brings to the view of inventive minds engaged therein opportunities for producing valuable practical devices*"

"*To achieve such results, careful choice of a ripe & promising field is prudent and a clear recognition of objectives certainly helps; but there should be no illusions about the necessity of a large measure of good luck*."

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"*..this work is obviously a product of the power and resourcefulness of the collaborative industrial group of talented physicists, chemists, metallurgists and engineers with whom he is associated*"