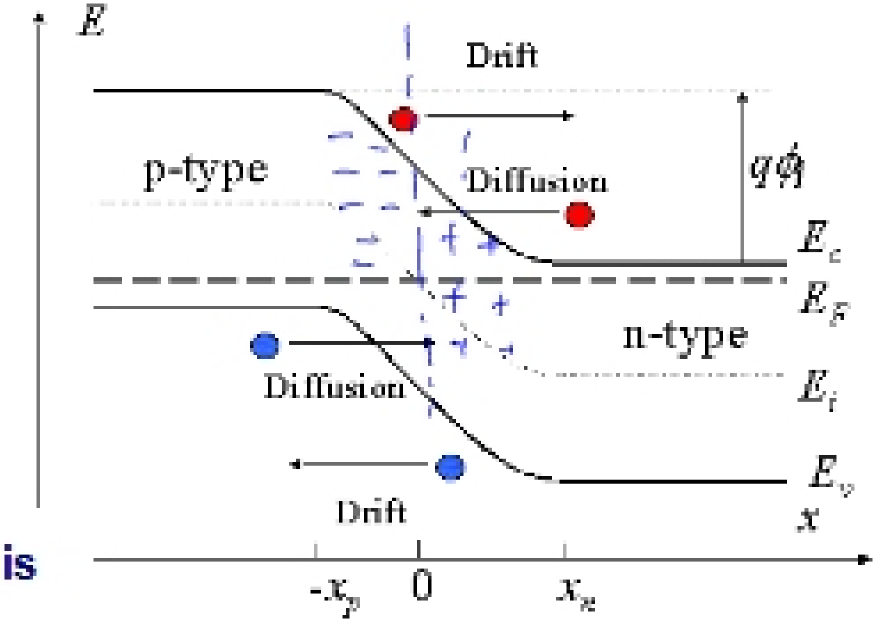
Electrostatic Analysis of a P-n junction

- As always, we start with Poisson's equation

$$\frac{d^2\phi}{dx^2} = -\frac{\rho}{\varepsilon_s} = -\frac{q}{\varepsilon_s}(p - n + N_d^+ - N_a^-)$$



Depletion Approximation

- Depletion region around the metallurgical junction is well-defined and abrupt
- Carrier concentration is given by the exponential function of the distance of the Fermi level from the band-edges; thus, carrier density drops to negligible value in the depletion region
- The net charge density in the depletion region is given by the ionized impurity concentrations yielding a constant charge density at least for uniformly doped junctions

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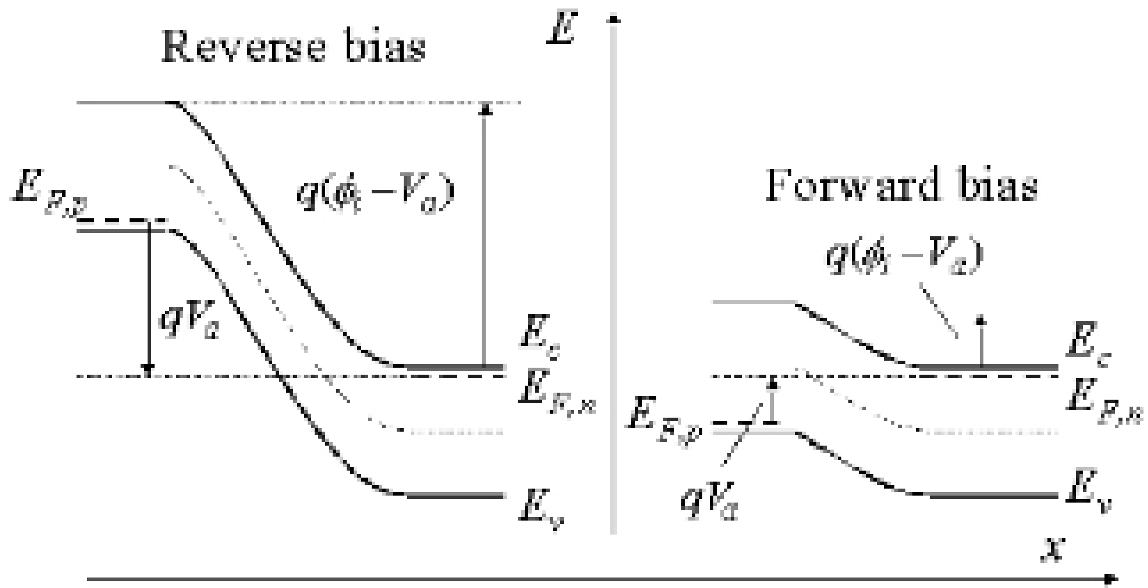
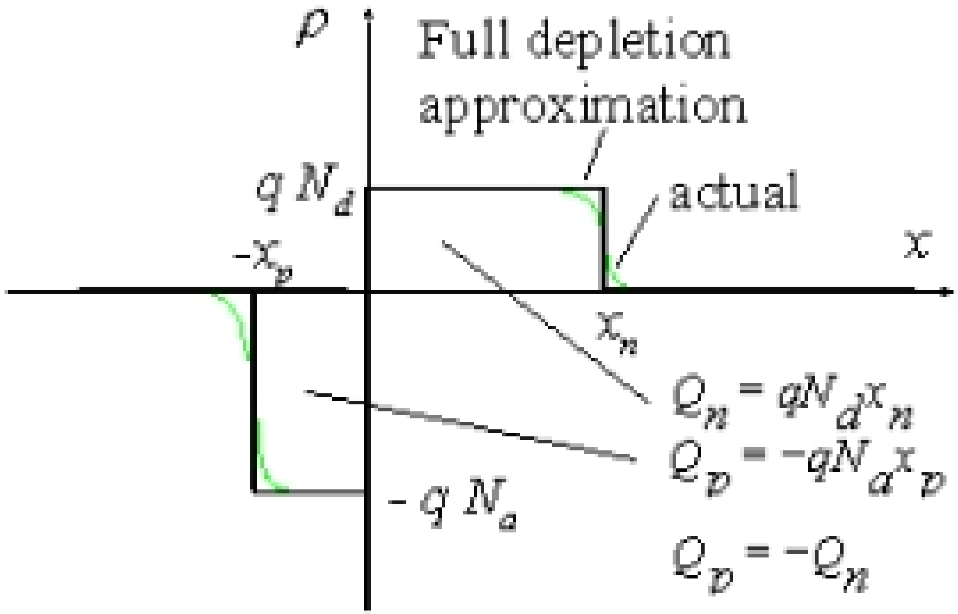


- **Steps for electrostatic analysis for p-n junction:**
  - **Introduce first 2 unknowns x_n (depletion width in n-type region) and x_p (depletion width in p-type region) such that the positive charge in the n-type region balances the negative charge in p-type region**
  - **Relate the potential across the two depletion regions to the applied bias across the junction (total band bending is $\phi_i - V_a$)**
  - **Solve for x_n and x_p**

Abrupt Uniformly doped P-n junction

First Step: Define x_n and x_p and match the depletion charge (apply depletion approximation to set all mobile charge to zero)



$$Q_n = Q_p$$

$$N_d x_n = N_a x_p \quad —$$