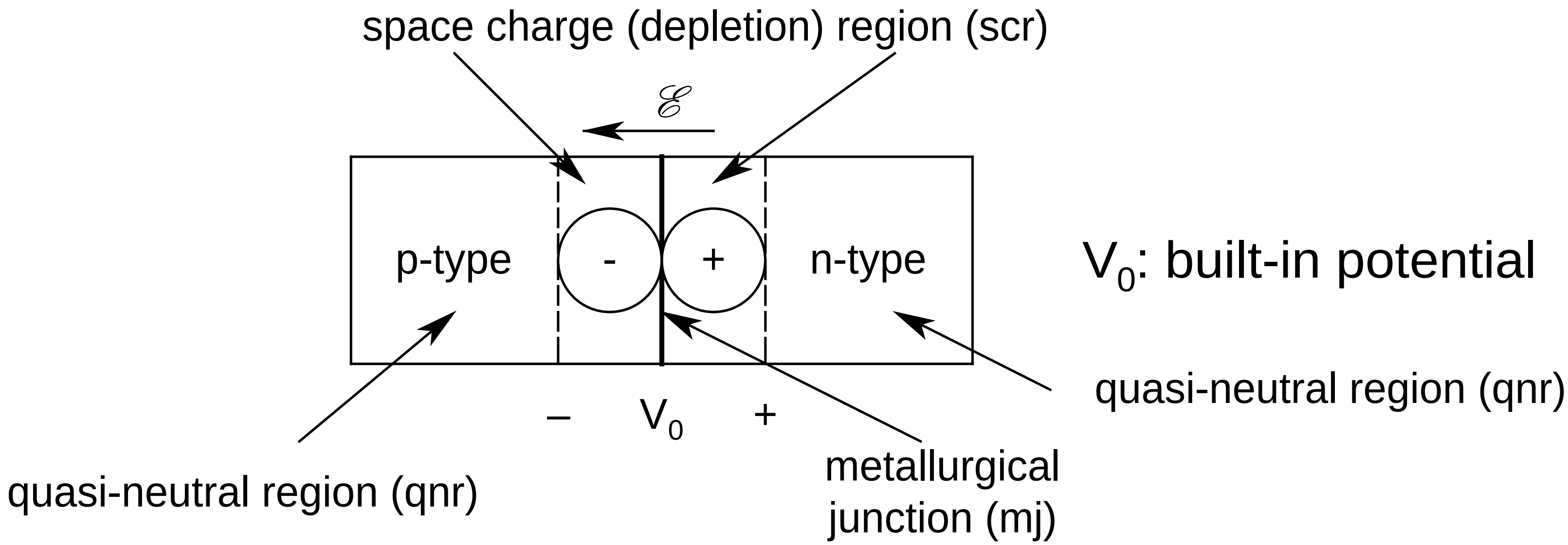


V_0: built-in potential

After Joining (In Equilibrium)

- ***Dissociation Relations***:

$$N_A \leftrightarrow N_A^- + \text{hole}$$

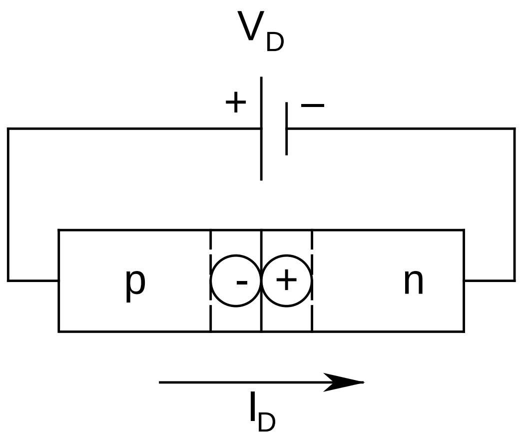
$$N_D \leftrightarrow N_D^+ + \text{electron}$$

Establishment of Equilibrium

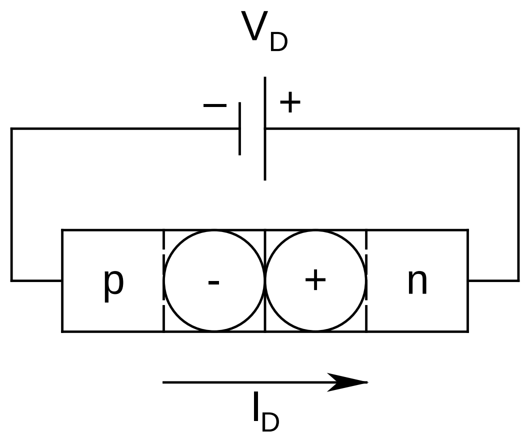
- ***Holes diffuse from p to n***
  - ***Negatively charged acceptor ions uncovered near MJ***
- ***Electrons diffuse from n to p***
  - **Positively charged donor ions uncovered near MJ**
- ***Establishment of a charge dipole around MJ***
  - ***Generation of an electric field $\mathscr{E}$ around MJ***
  - ***Creation of built-in potential V_0***

- ***$\mathscr{E}$ creates drift components of carriers***
  - ***Holes pushed back to p***
  - ***Electrons pushed back to n***
- When these two motions (***drift and diffusion***) completely ***balance out***
  - ***Equilibrium*** is reached
- Under this condition, the ***net fluxes*** of ***both electrons and holes*** across MJ are ***zero***
  - ***No net current flows through the device***

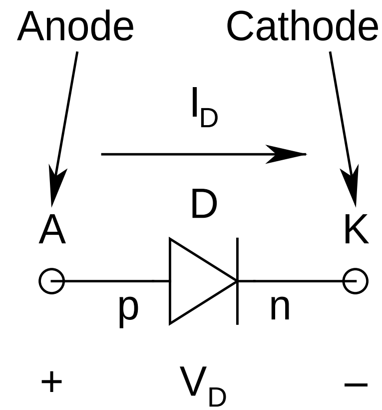
Diode Under Bias



Forward Bias:
p-side positive w.r.t. n-side



Reverse Bias:
n-side positive w.r.t. p-side



Symbol and current-voltage convention

Voltage and Current Conventions:

V_D: 0 (Equilibrium), Positive (Forward Bias), Negative (Reverse Bias)

I_D: p to n (Positive), n to p (Negative)

- ***Forward Bias*** (***V_D positive***):
  - ***p positive w.r.t. n***
  - ***Depletion region width***$\downarrow$
  - ***Electric field across MJ***$\downarrow$
    - ***Barrier height*** $(V_0 - V_D)\downarrow$
  - ***Injection of holes from p to n and electrons from n to p***$\uparrow\uparrow$ (***thermionic emission***)
    - ***Diffusion component***$\uparrow\uparrow$ ***while drift current remains more or less same***
  - ***Net current from p to n*** (***can be large***)
    - Known as ***forward current*** (***I_D positive***)

- ***Reverse Bias*** (***V_D negative***):
  - ***p negative w.r.t. n***
  - ***Depletion region width*** ↑
  - ***Electric field across MJ*** ↑
    - ***Barrier height (V_0 + $|V_D|$)*** ↑
  - ***Injection of holes from p to n and electrons from n to p*** ↓↓ (known as ***carrier extraction***)
    - ***Diffusion component*** ↓↓ ***while drift current remains more or less same***
  - ***Net current from n to p*** (***miniscule***!)
    - Known as ***reverse current*** (***I_D negative***)

More on Forward & Reverse Currents

- ***Injection of carriers***: Inj $\propto$ exp[– BH/V_T)
  - BH: ***Barrier Height***
  - V_T (= kT/q): ***Thermal Voltage*** [26 mV at room temperature (300 K)]
- ***Under equilibrium***:
  - Inj $\propto$ exp($-V_0/V_T$)
  - ***Exactly balanced by the opposing drift component*** $\Rightarrow$ ***net current = 0***