DELD

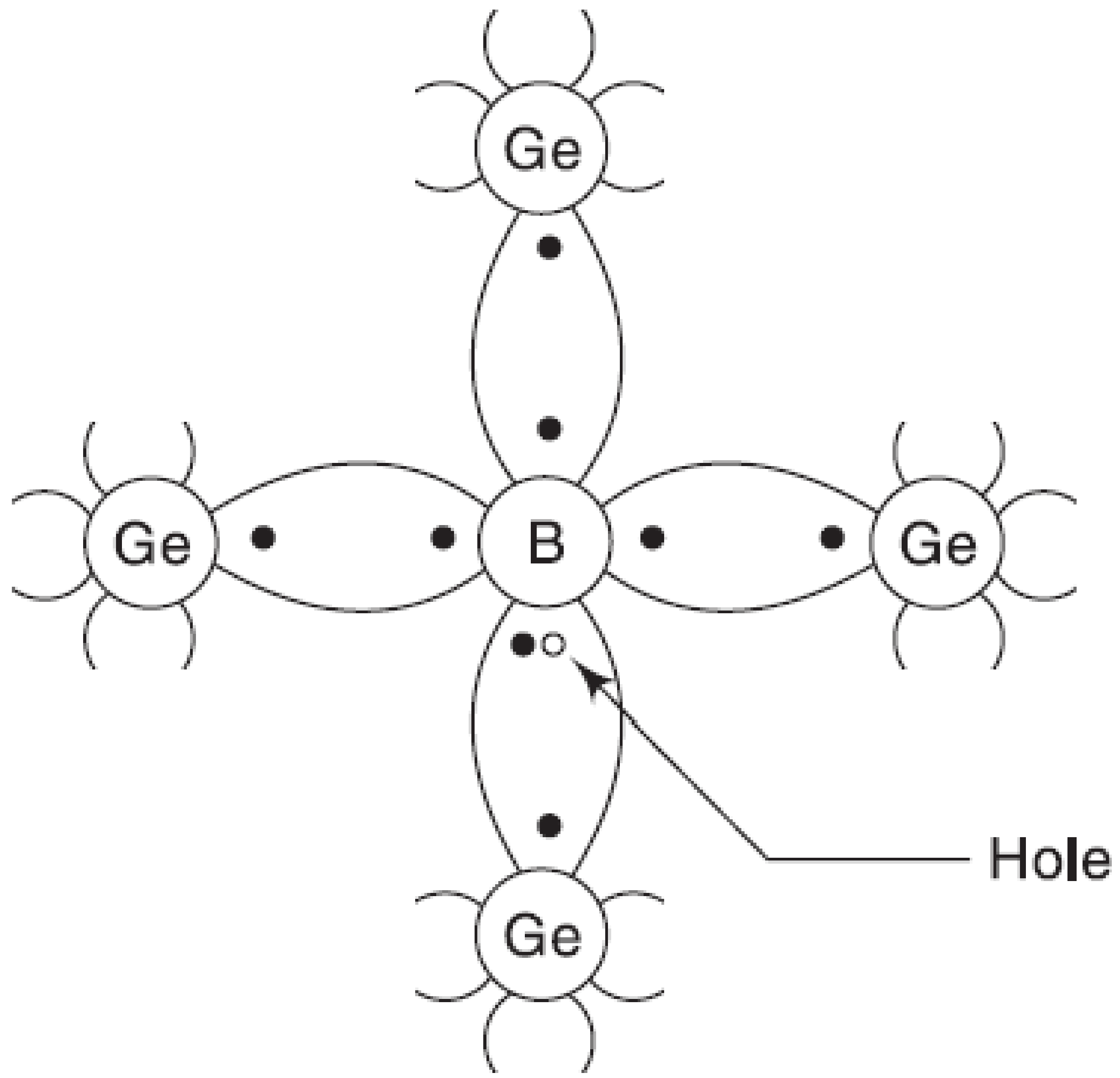
Unit 1

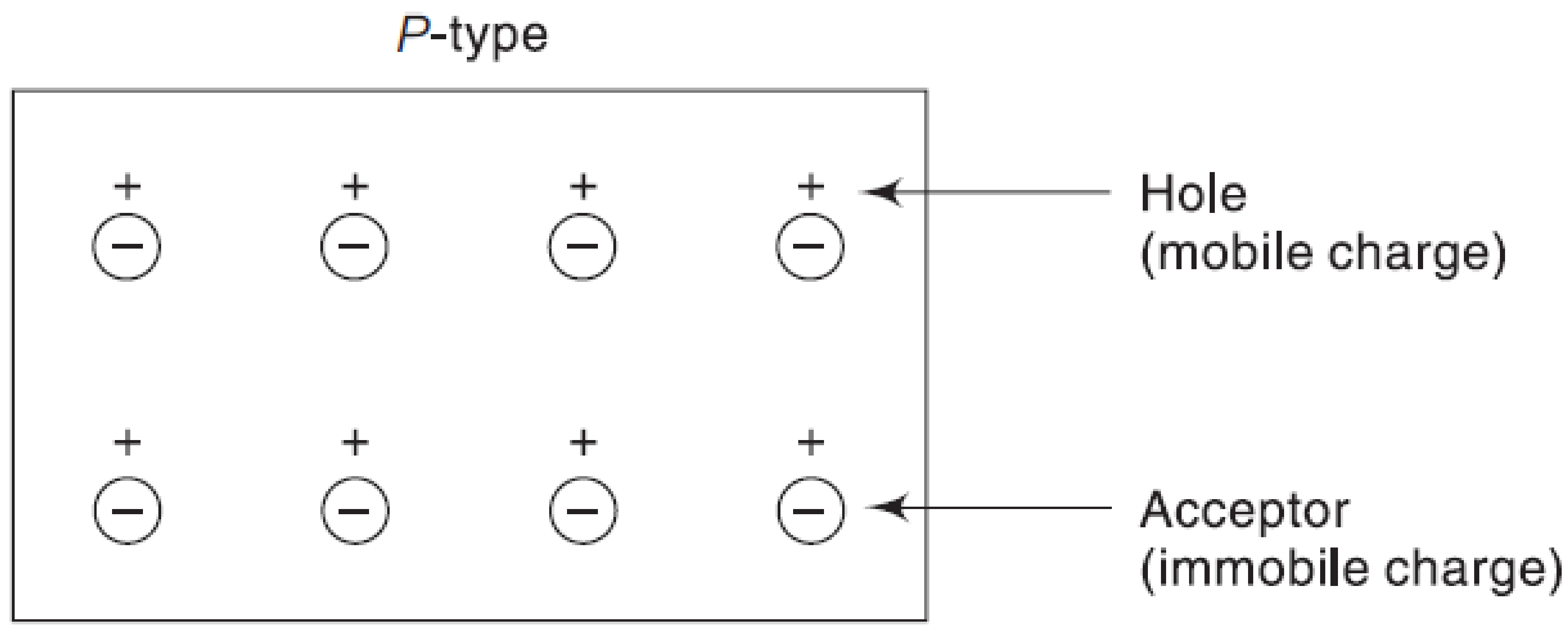
PN Diode and Transistor

Electronics Engineering Department

P – Type Semiconductor

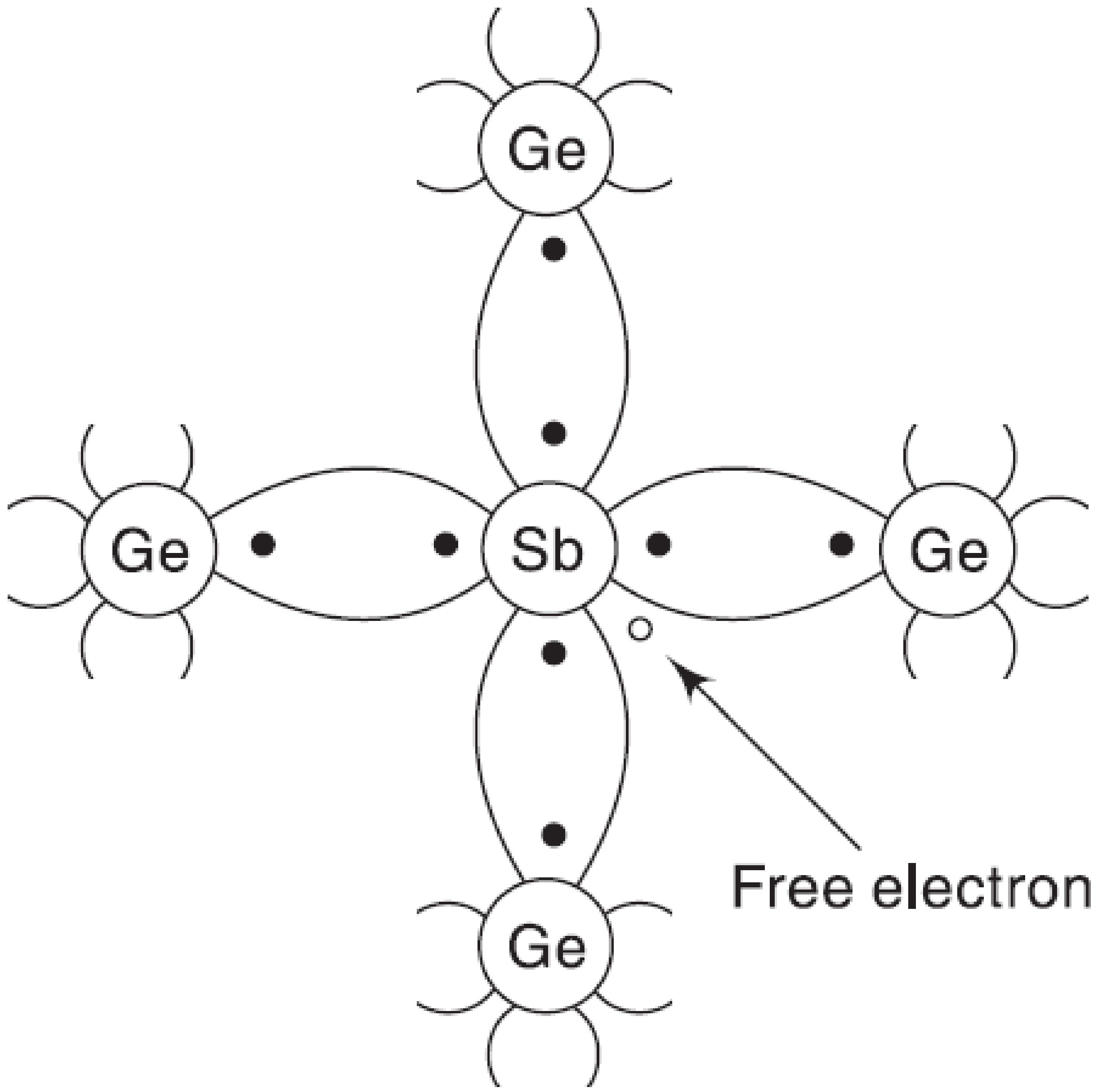
Germanium doped with Boron (Trivalent Impurity)

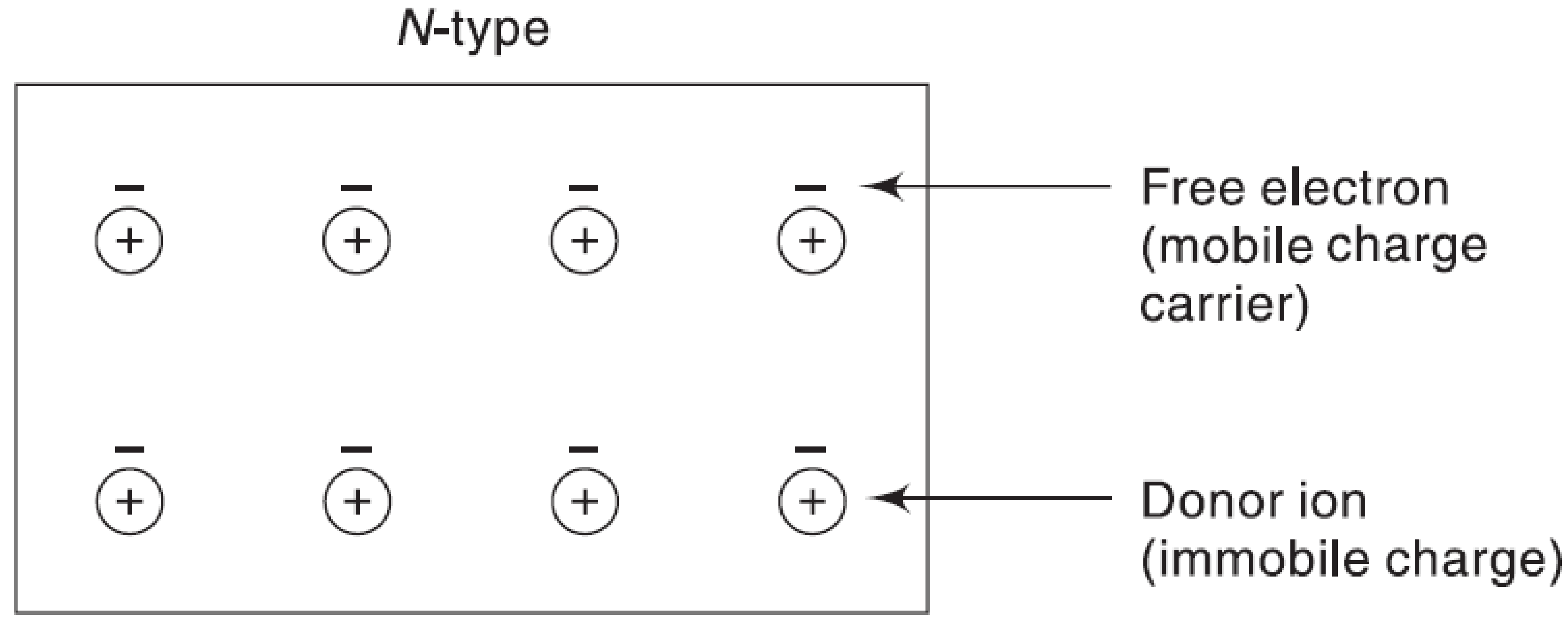




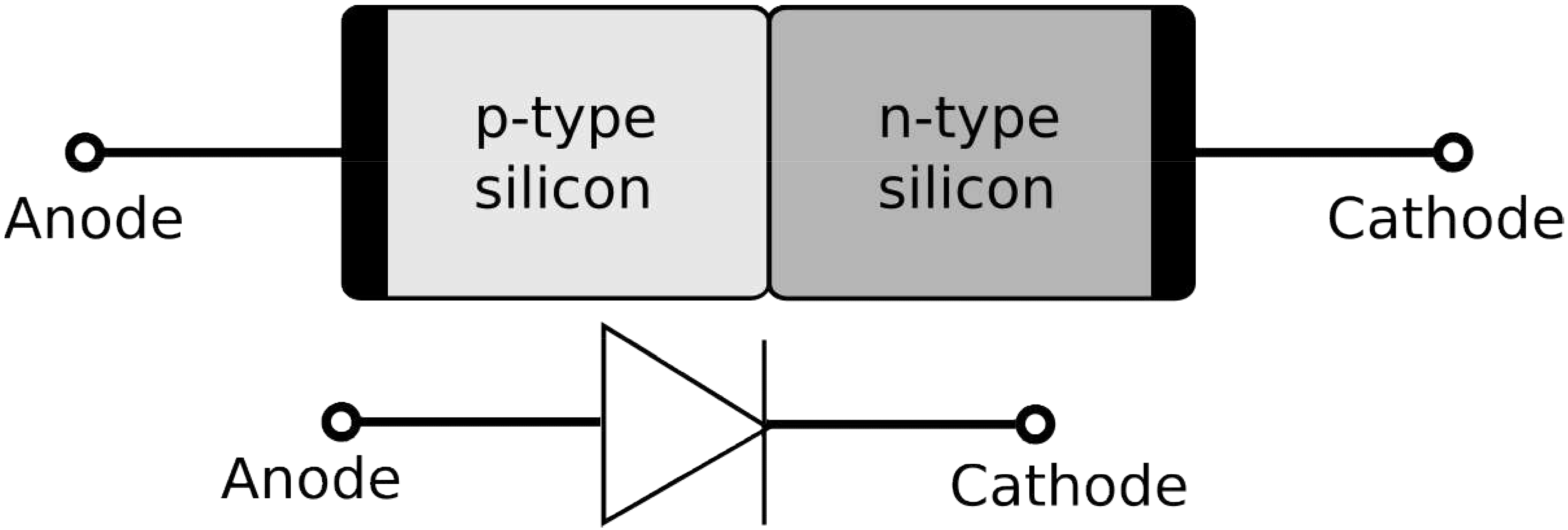
N – Type Semiconductor

Germanium doped with Antimony (Pentavalent Impurity)

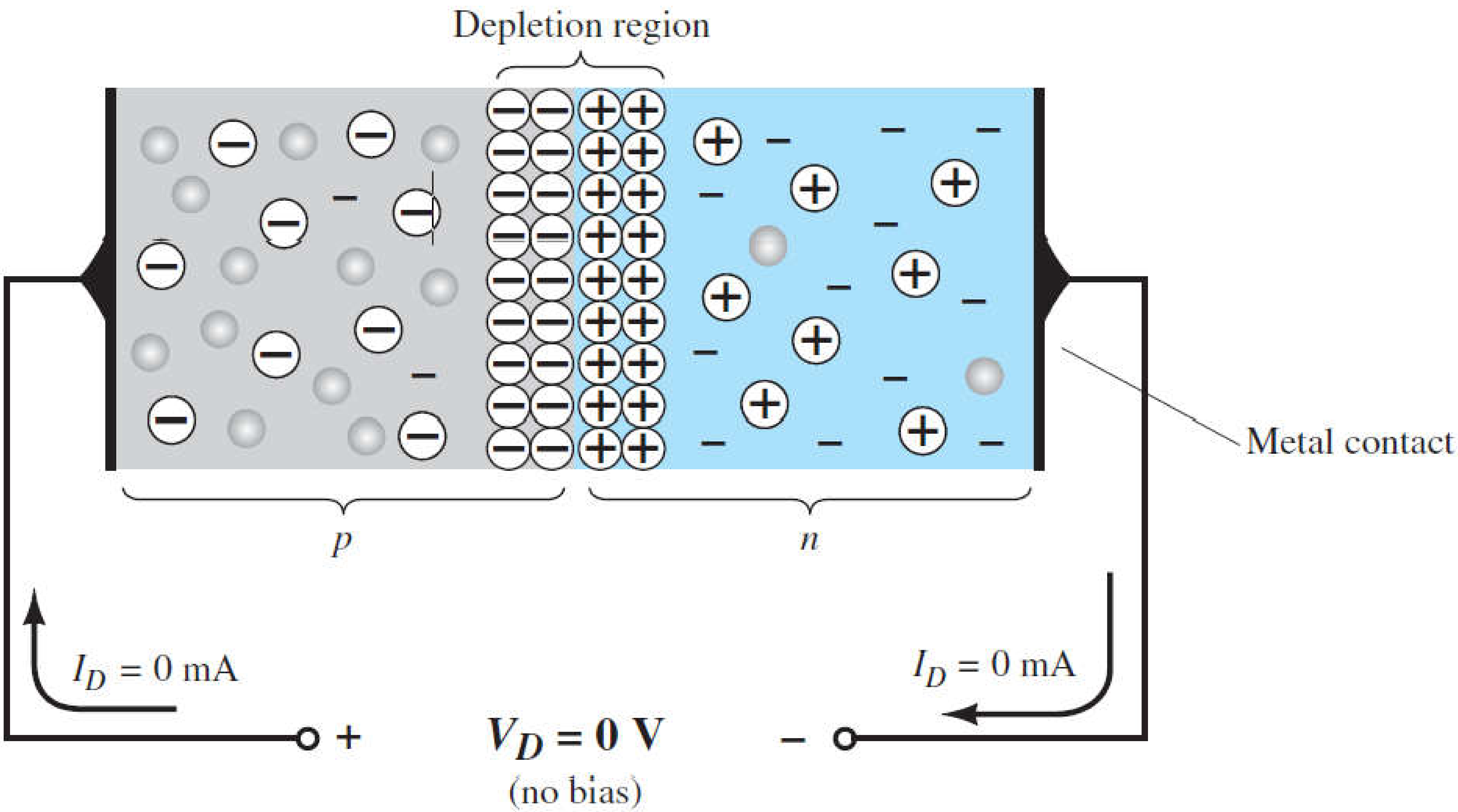




PN Junction



Depletion Layer



Depletion Layer

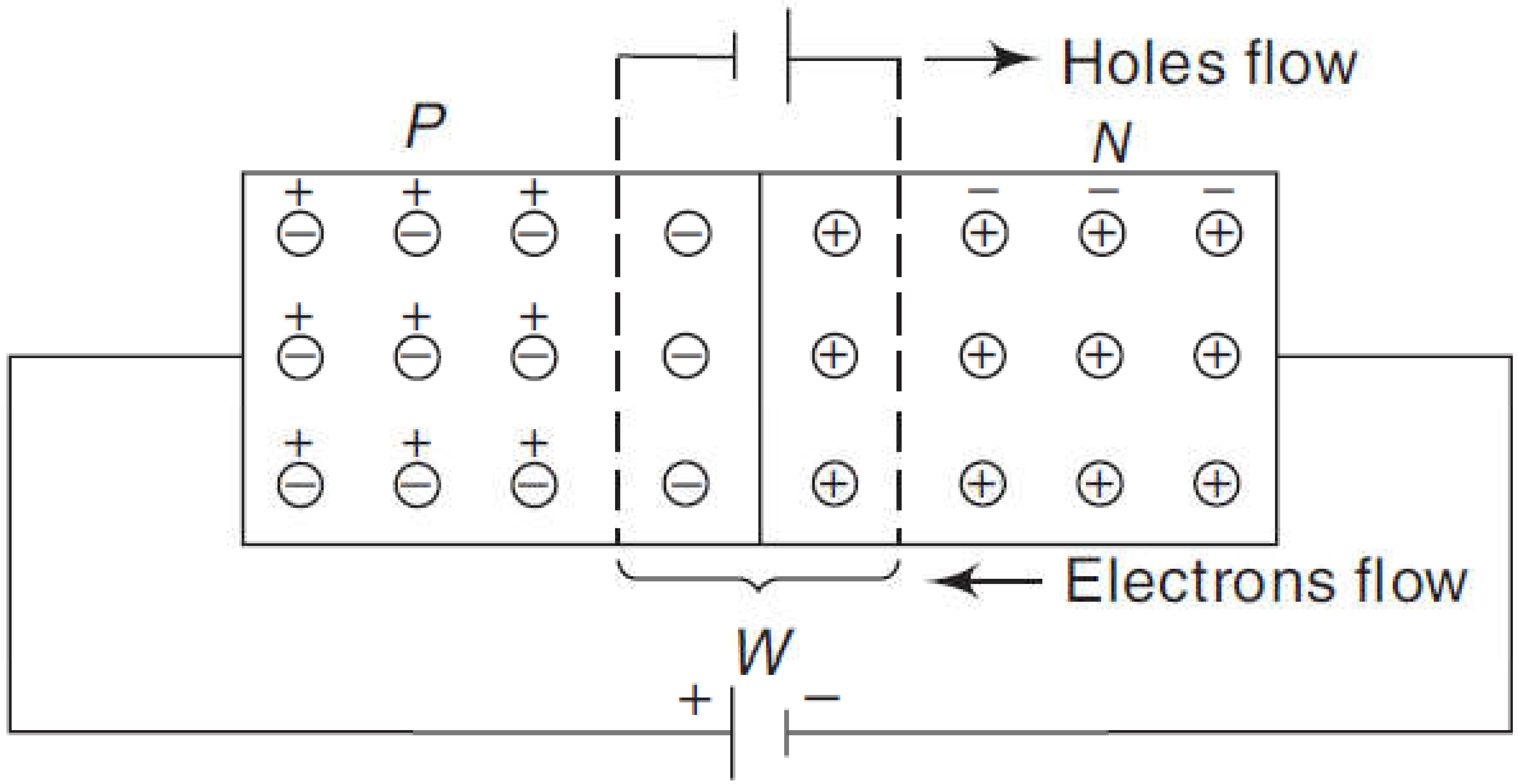
- The excess electrons in the N- Region cross the junction and combine with the excess holes in the P – region.
- N- Region looses electrons and becomes positively charged
- P - Region looses holes and becomes negatively charged
- At some point this migration stops (Concentration becomes same)
- Any additional electrons from N side are repelled by the negative charge of the P – Region
- Similarly, additional holes from the P side are repelled by the positive charge of the N –Region

Depletion Layer Cont…

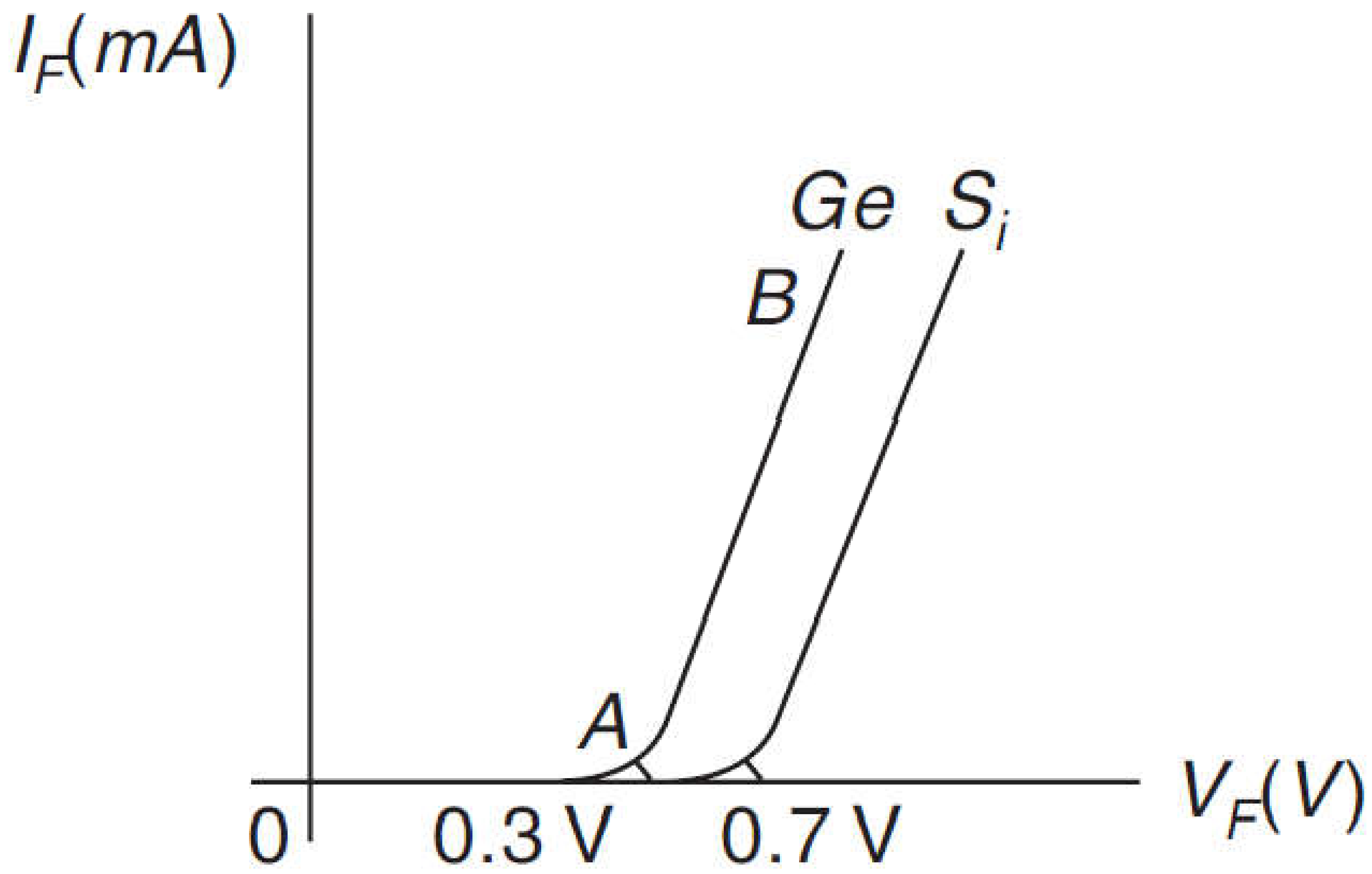
- This results in a thin layer on both the sides at the junction which contains only immobile charge carriers. This is known as depletion layer. Range is in micrometers
- Width depends on doping
- Heavily doped – less width and vice-versa
- Electrons in the N region have to climb the potential hill in order to reach the P – Region. This potential is known as Potential Barrier.
- Ge – 0.3 volts, Silicon – 0.7 volts

Forward Bias

- ❑ Positive terminal of the battery is connected to p-region and negative terminal is connected to n-region
- ❑ Width of depletion layer decreases
- ❑ Current flows in the forward direction and diode acts as a short circuit



Forward Characteristics



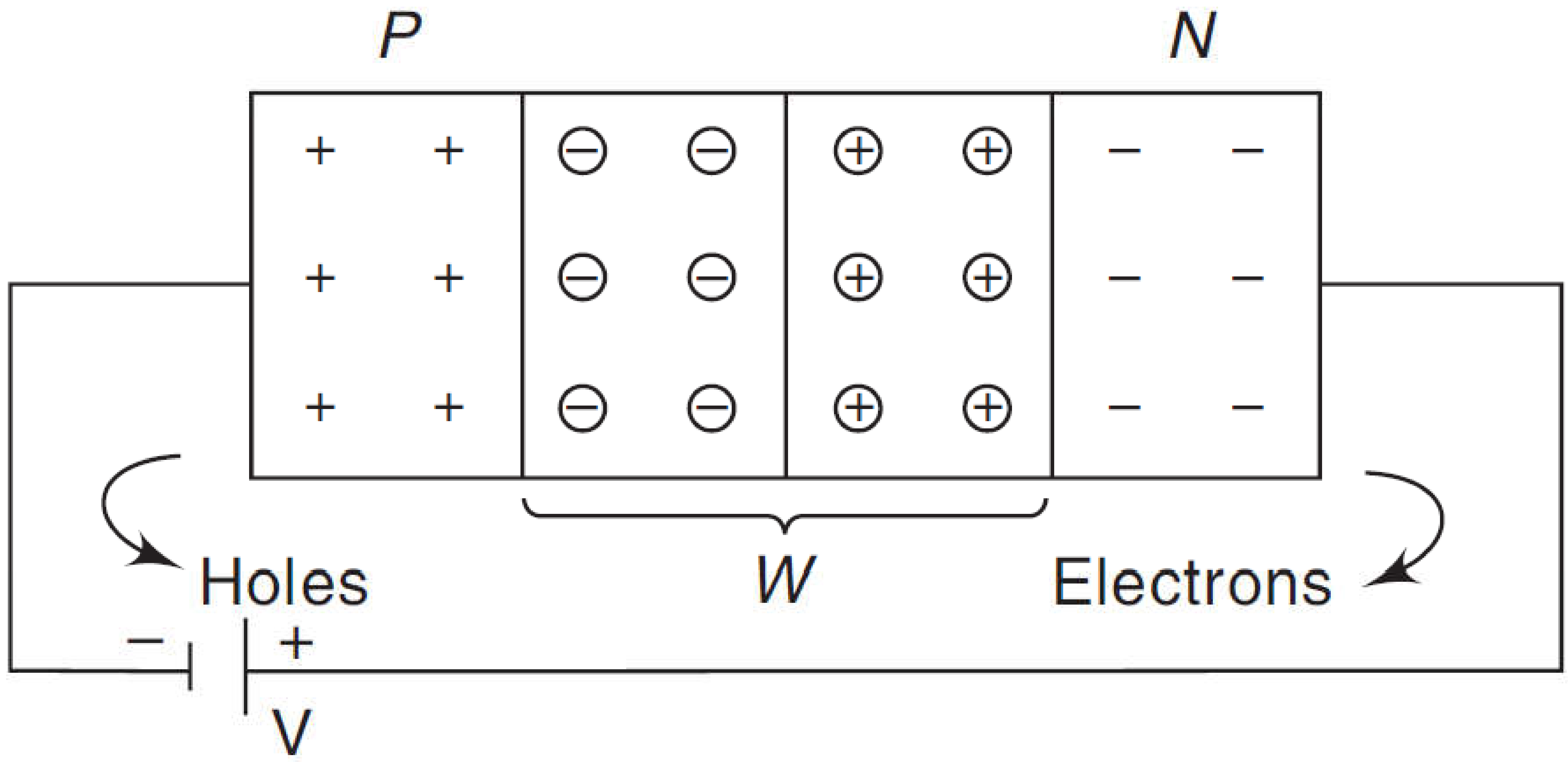
Diode Equation

$$\boxed{I_D = I_s(e^{V_D/nV_T} - 1)}$$

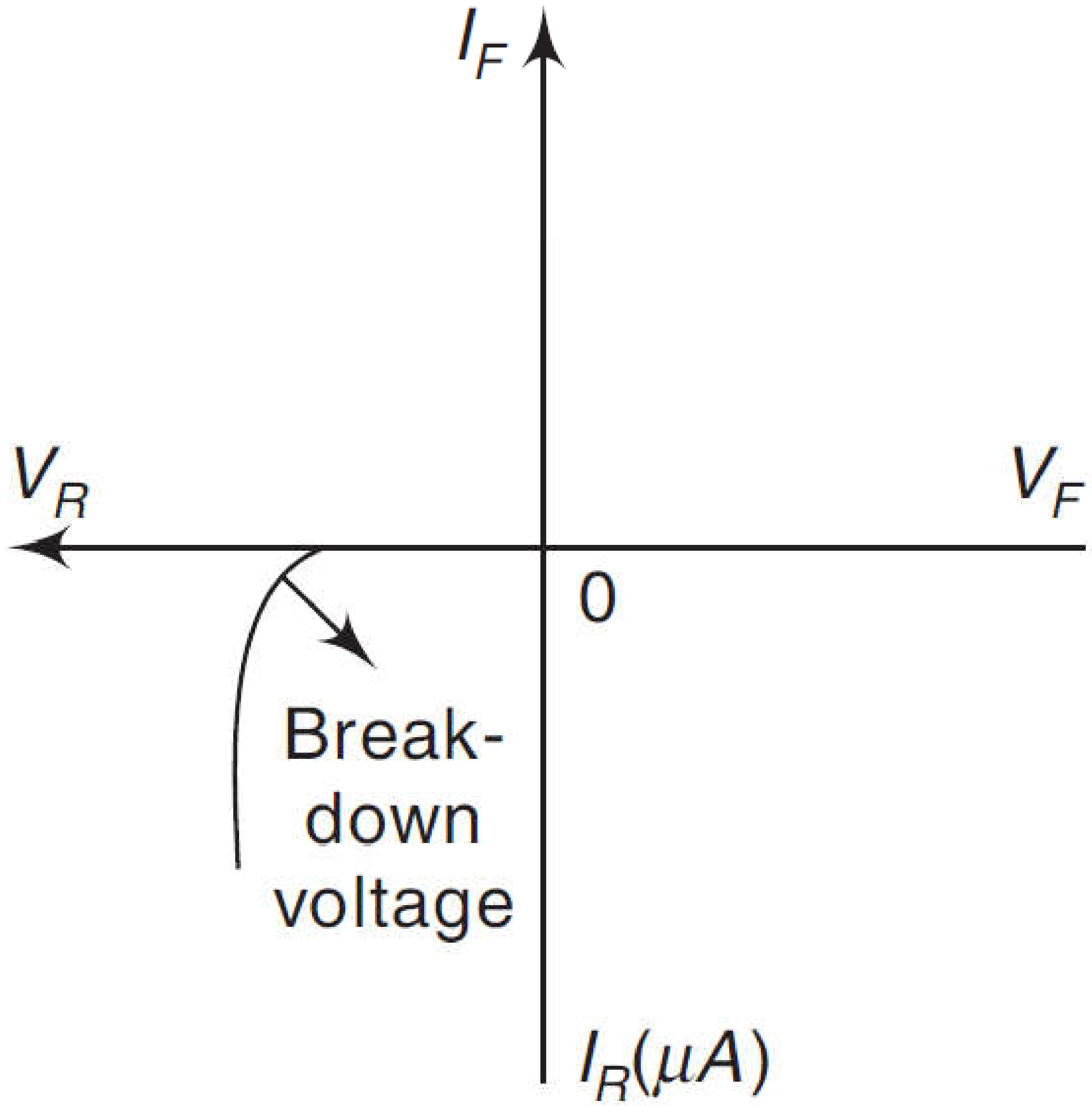
- ❑ Is – Reverse Saturation Current
- ❑ Vd is the applied Forward Biased voltage
- ❑ n – Ideality Factor (if not mentioned, assume as 1)
- ❑ Vt – Thermal voltage (25 milli volts at room temperature: 27 degrees/300 degree K)

Reverse Bias

- ❑ Positive terminal of the battery is connected to N – side and Negative terminal of the battery is connected to P – Side
- ❑ The free electrons and the free holes are attracted back towards both the battery terminals
- ❑ The charge carriers move away from the depletion layer
- ❑ Width of depletion layer increases
- ❑ No current flows and the diode acts as an open circuit



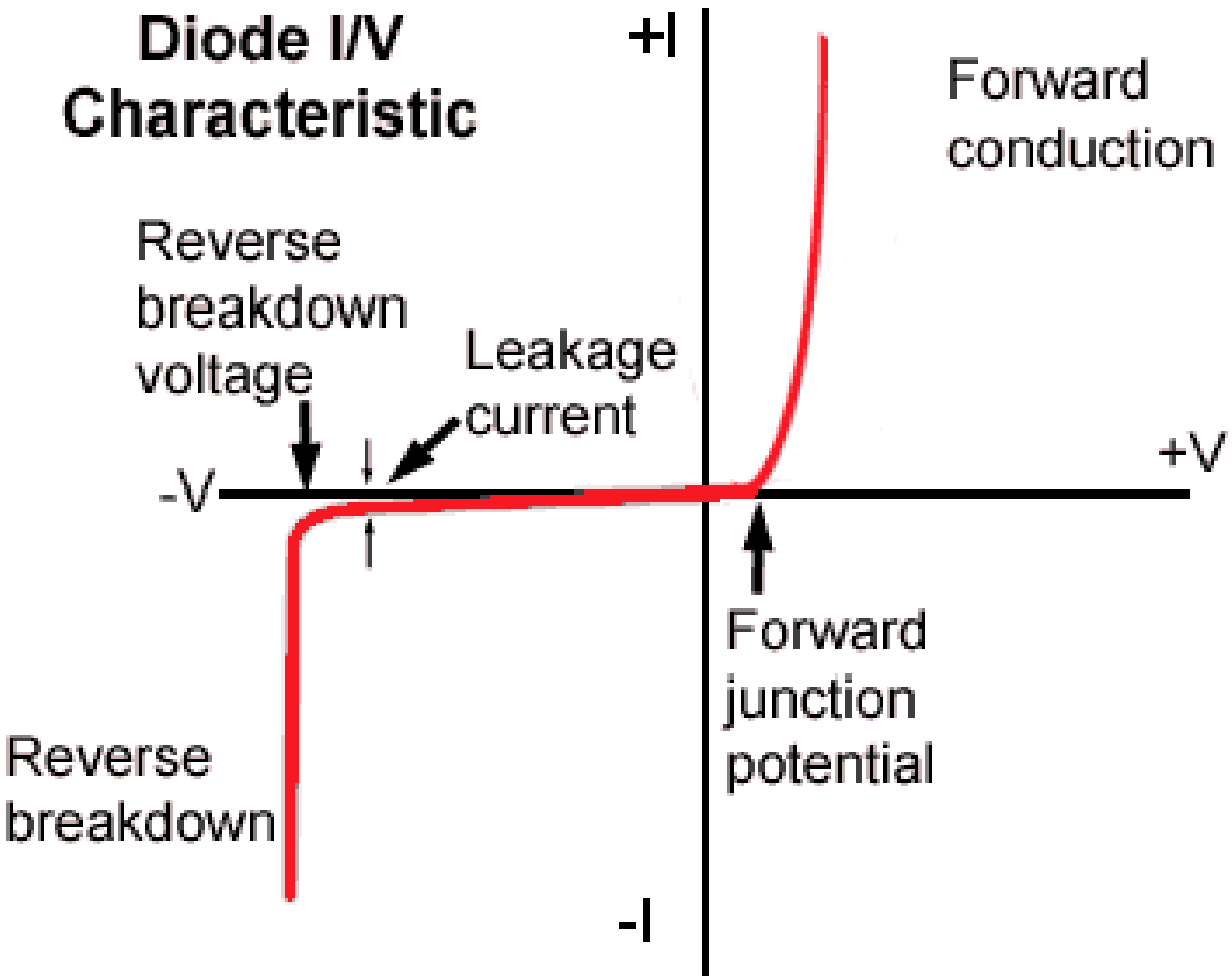
Breakdown Voltage



❑ Go on increasing the reverse bias. At certain voltage, The current increases at a very rapid rate in a direction opposite to that of the positive voltage region.

❑ The reverse-bias potential that results in this dramatic change in characteristics is called the **Breakdown Voltage**.

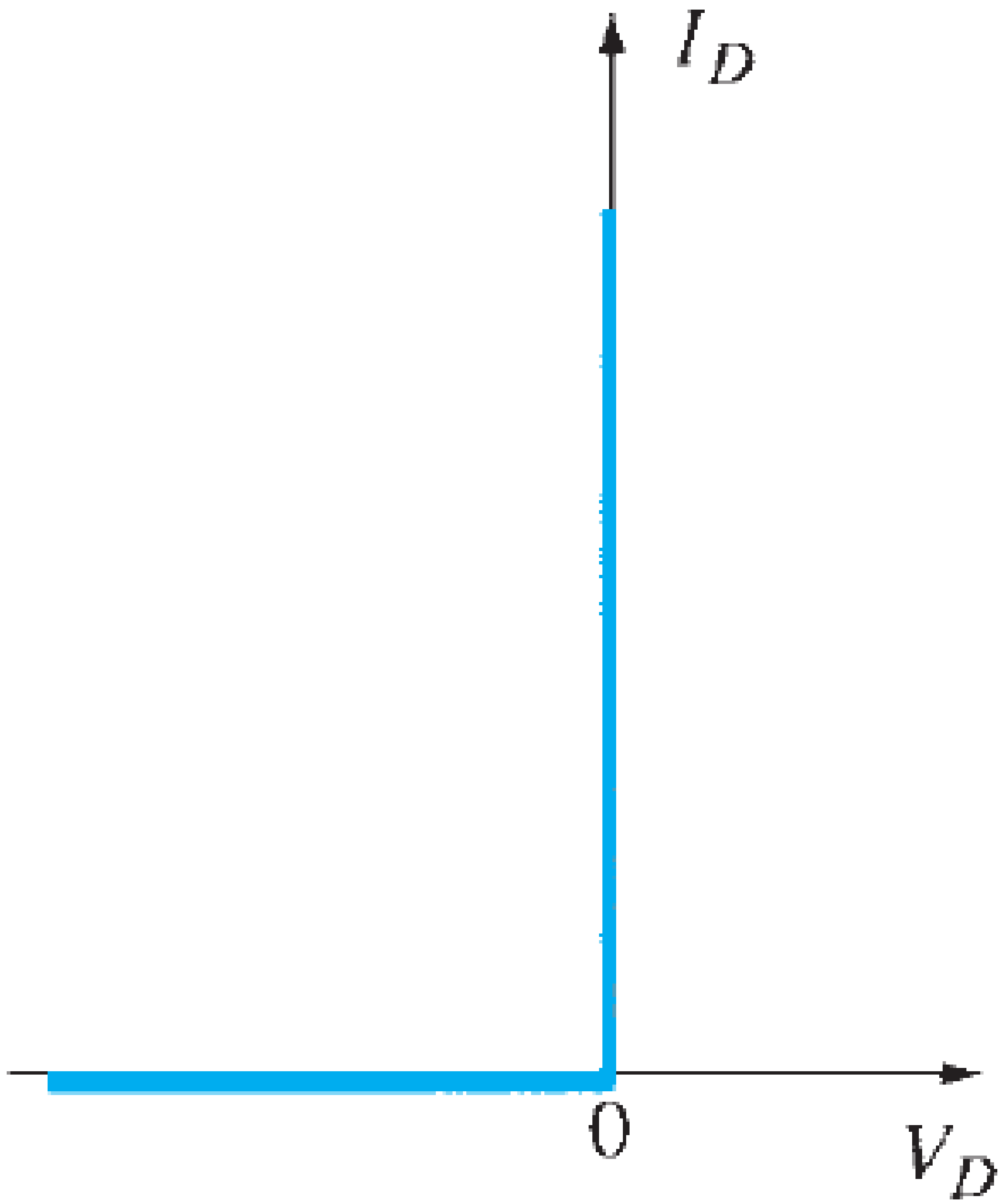
Diode Characteristics

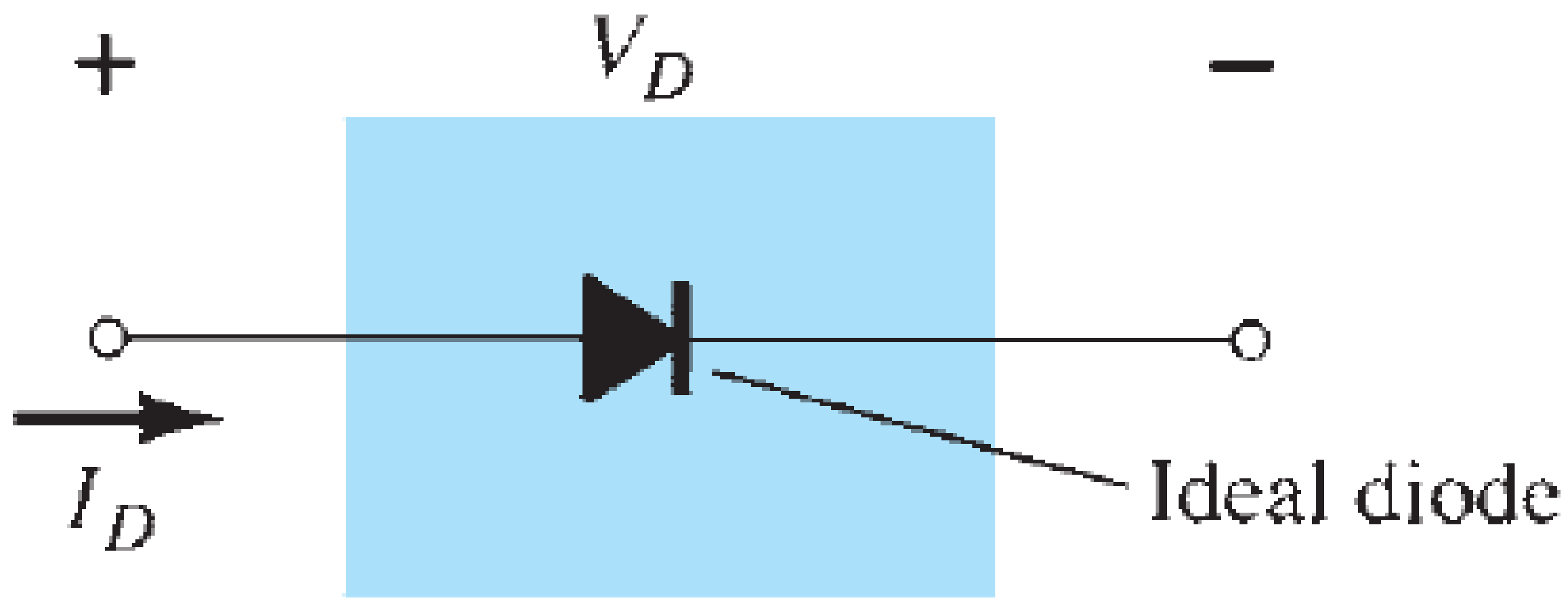


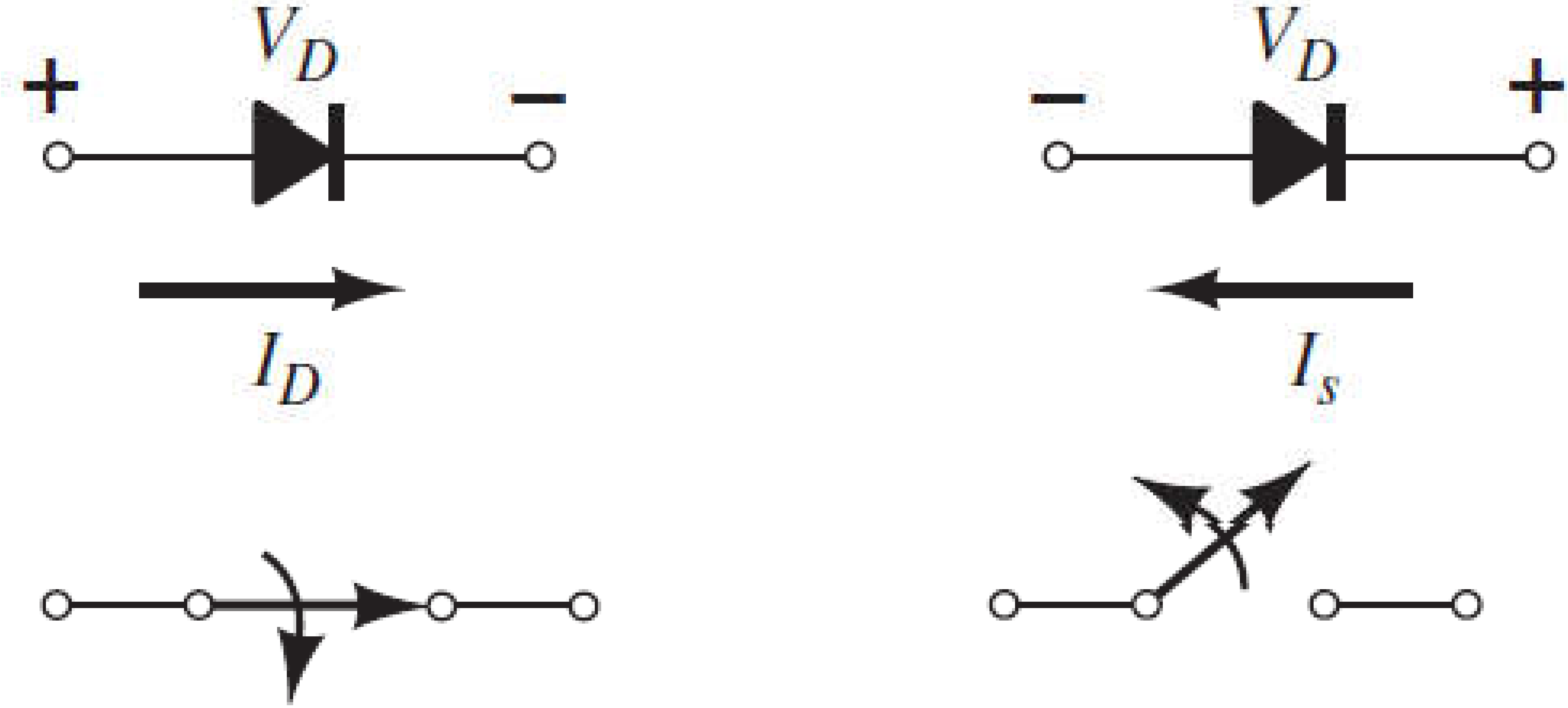
Equivalent Circuits

Ideal Diode

Diode will behave as short circuit as soon as the voltage across it becomes greater than zero



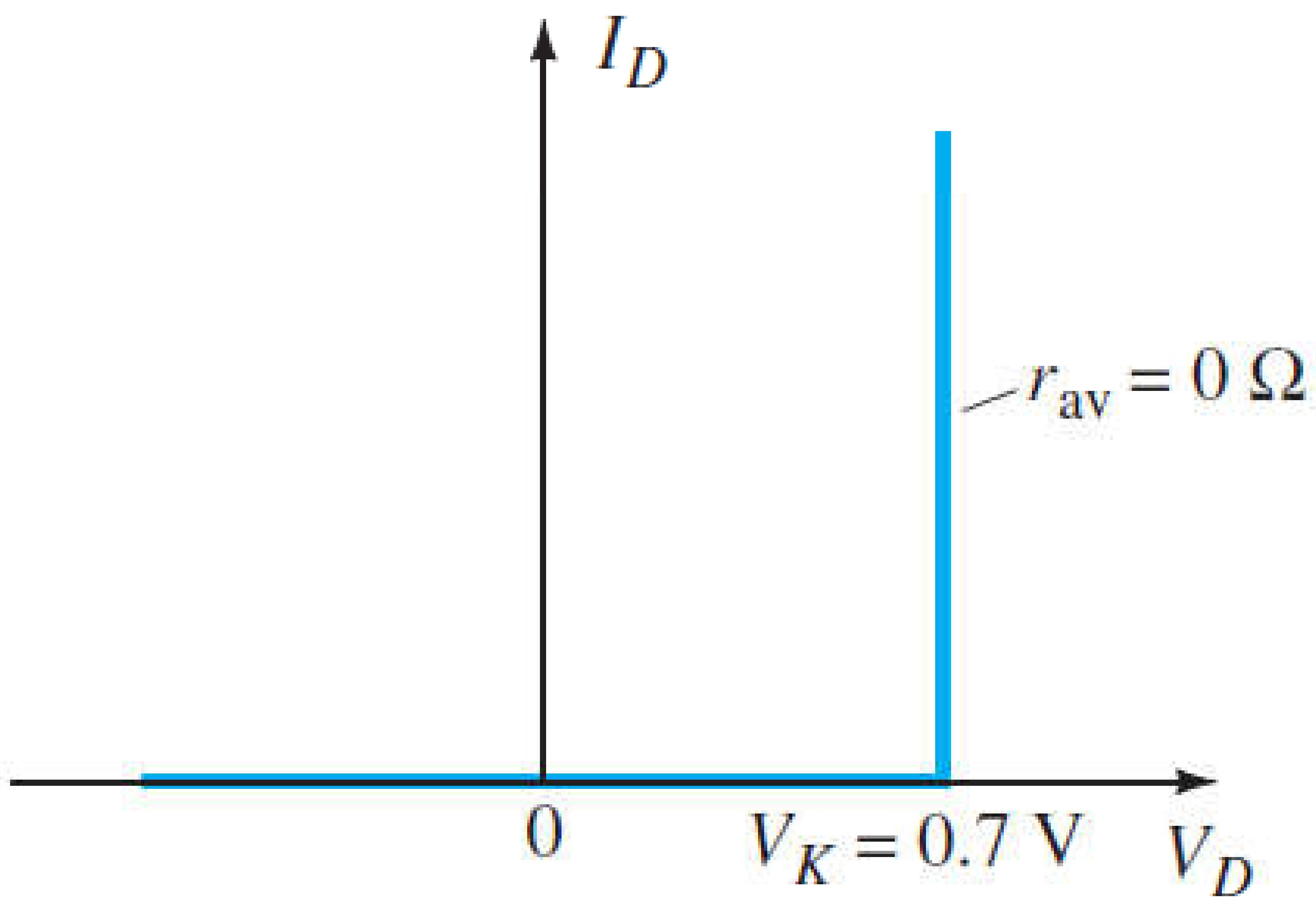


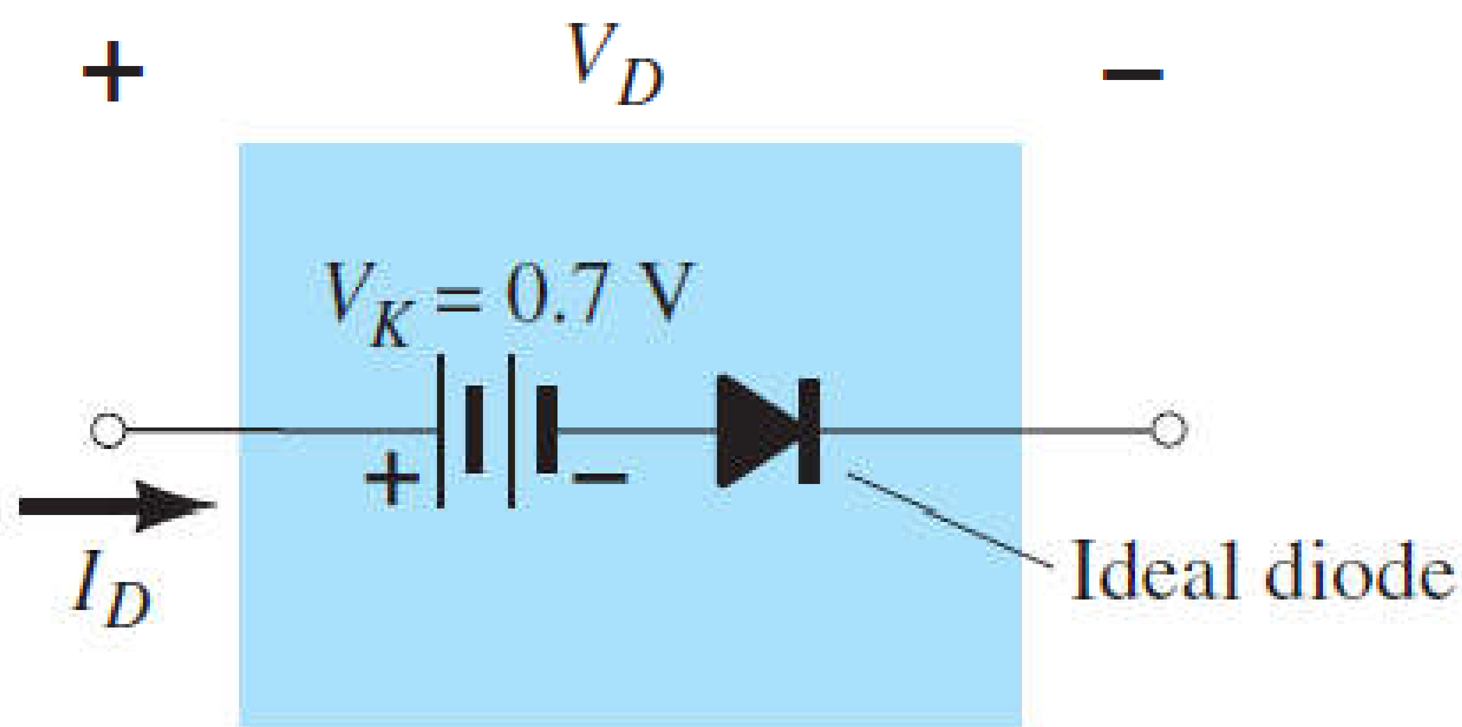


+
V_D
−
I_D
−
V_D
+
I_s

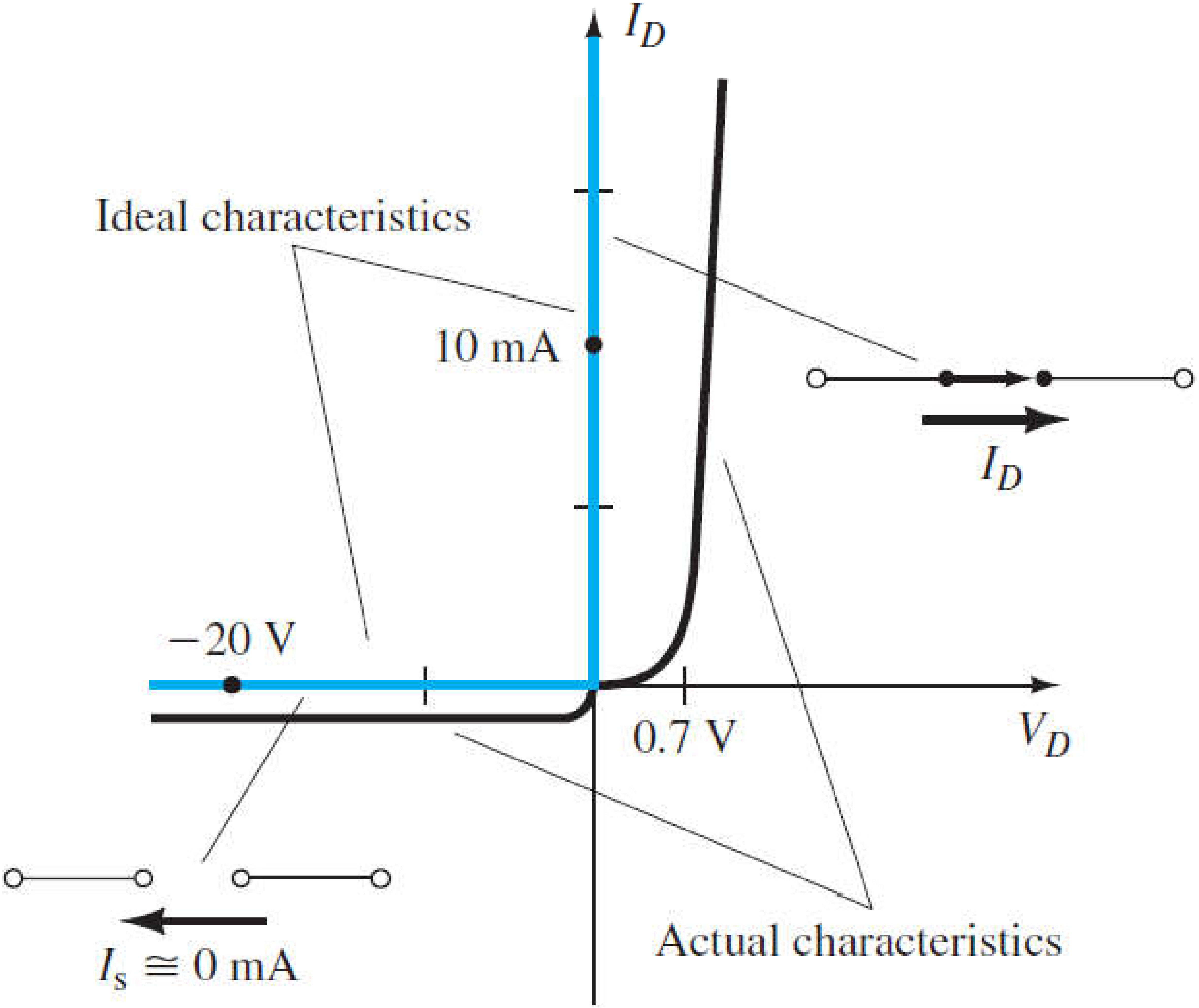
Practical Diode

We must overcome the potential barrier of 0.7 volts (silicon) for a diode to make it forward bias



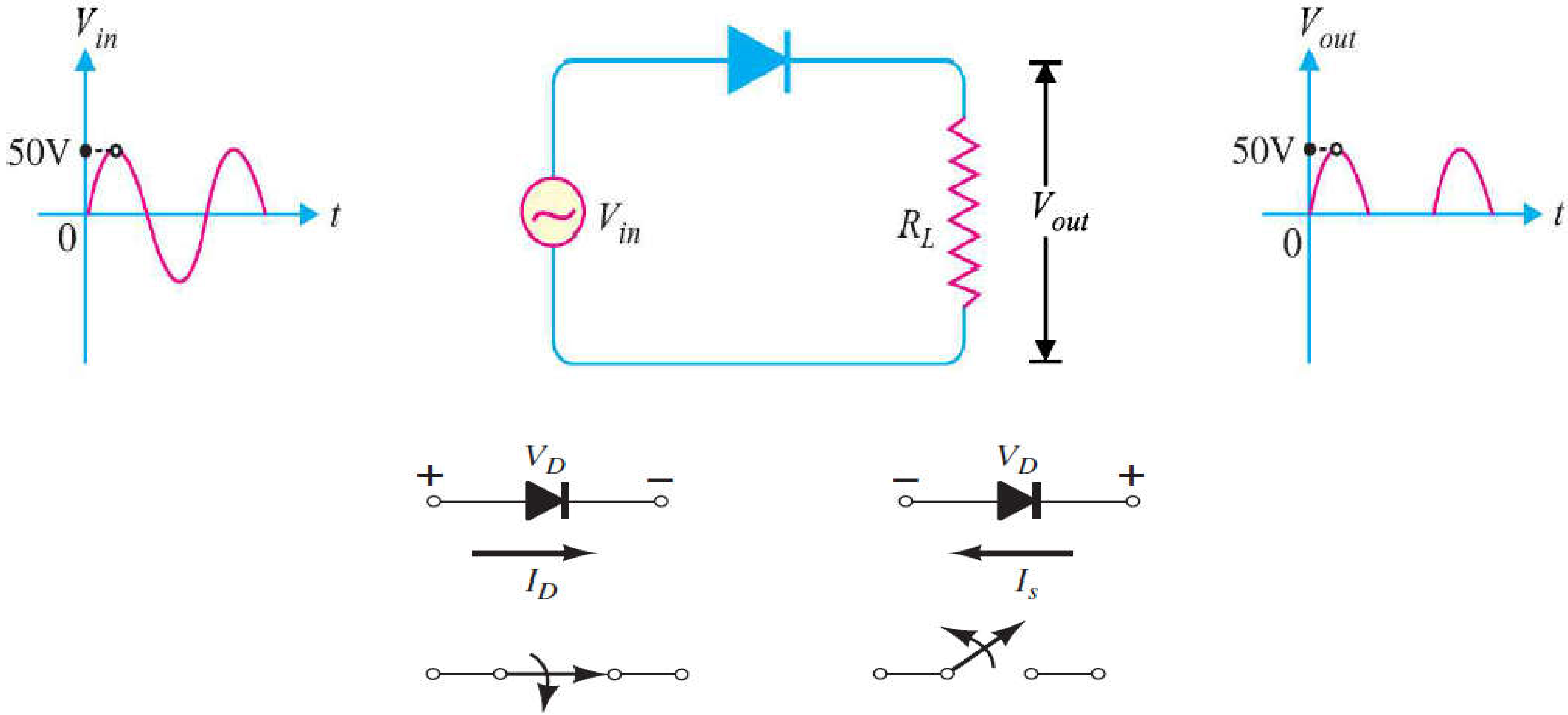


Ideal vs. Actual Characteristics



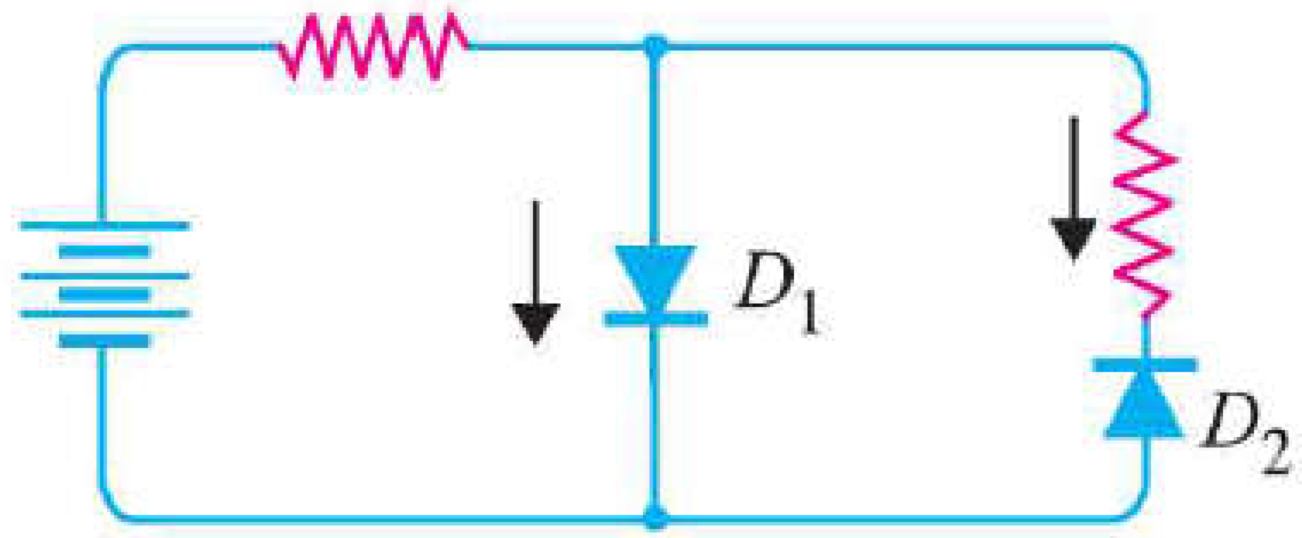
Diode as a Rectifier

- Diode behaves as a switch
- Forward Biased – Closed Switch, connects AC Supply to load
- Reverse Biased – Open Switch, disconnects AC with load

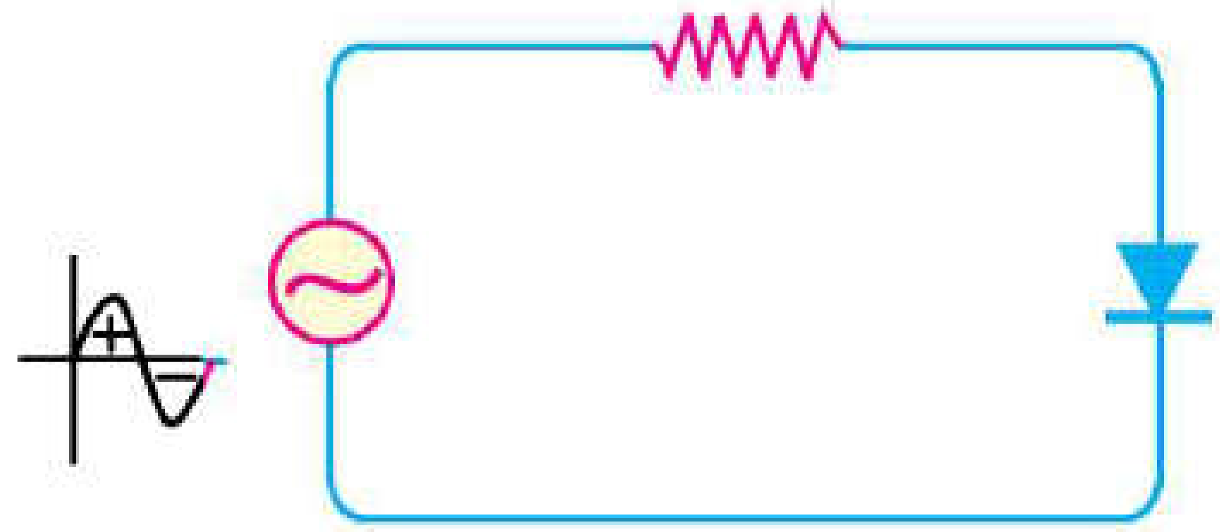


Concept Check…

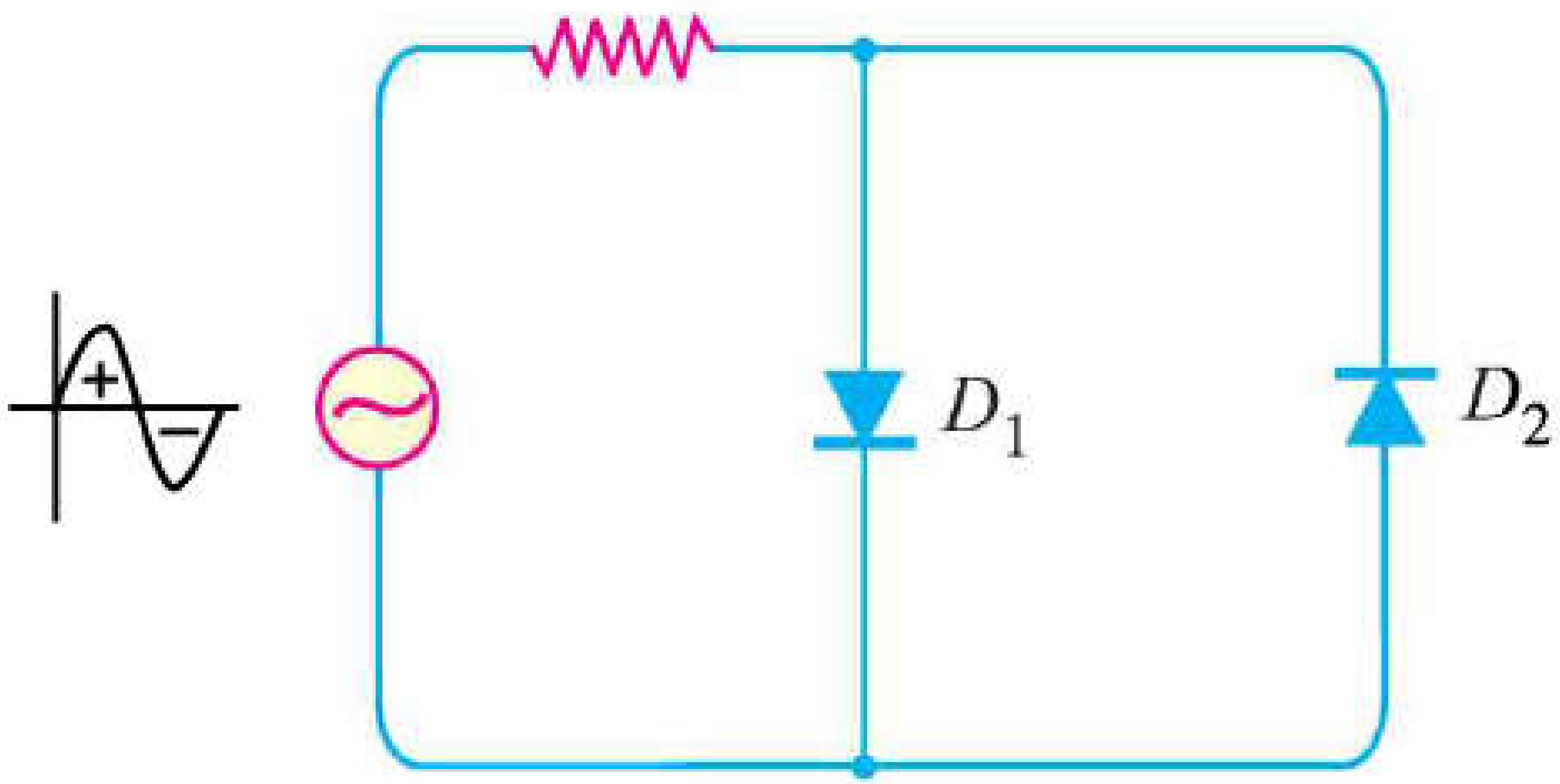
Identify whether the diode/diodes is/are forward or reverse biased?



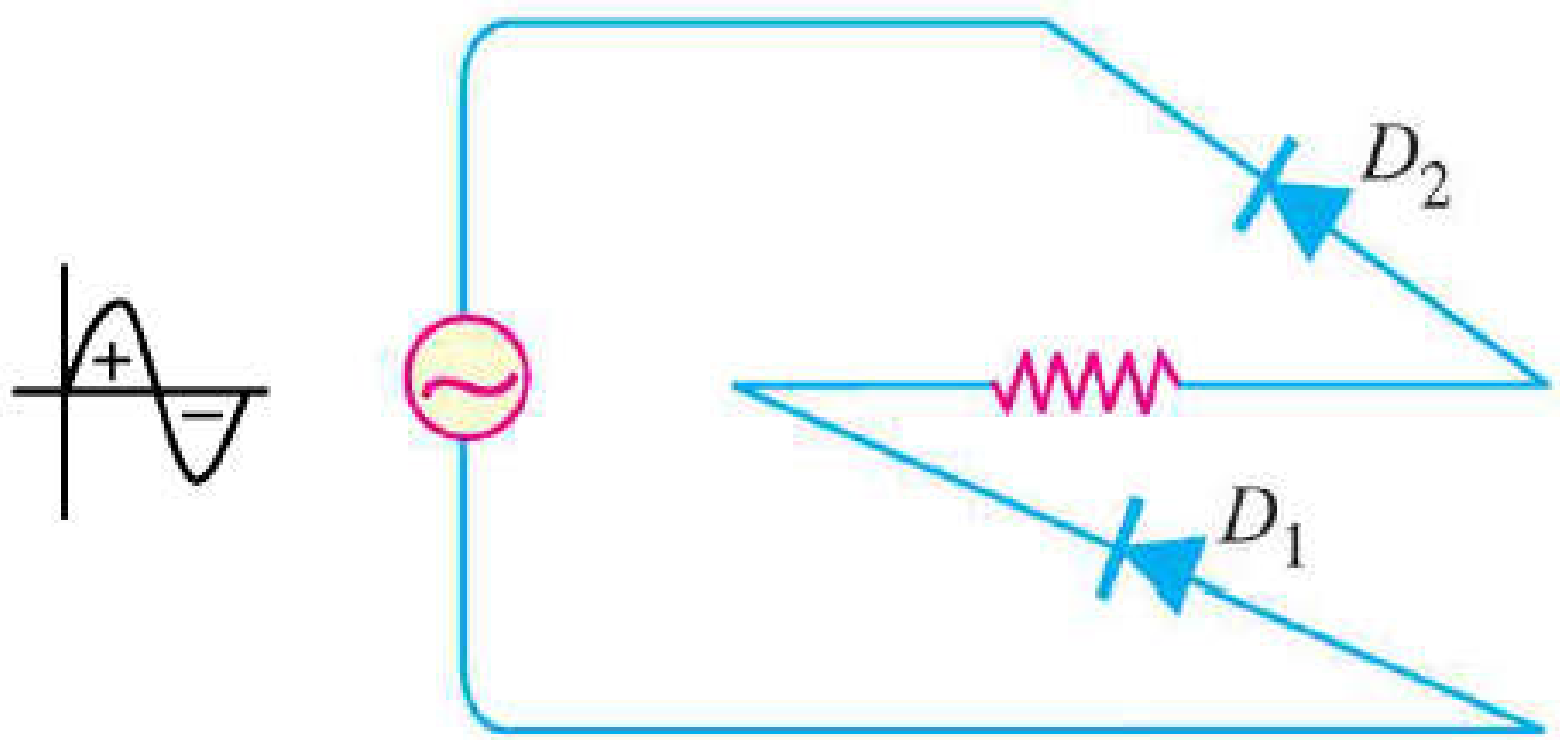
(*i*)



(*ii*)



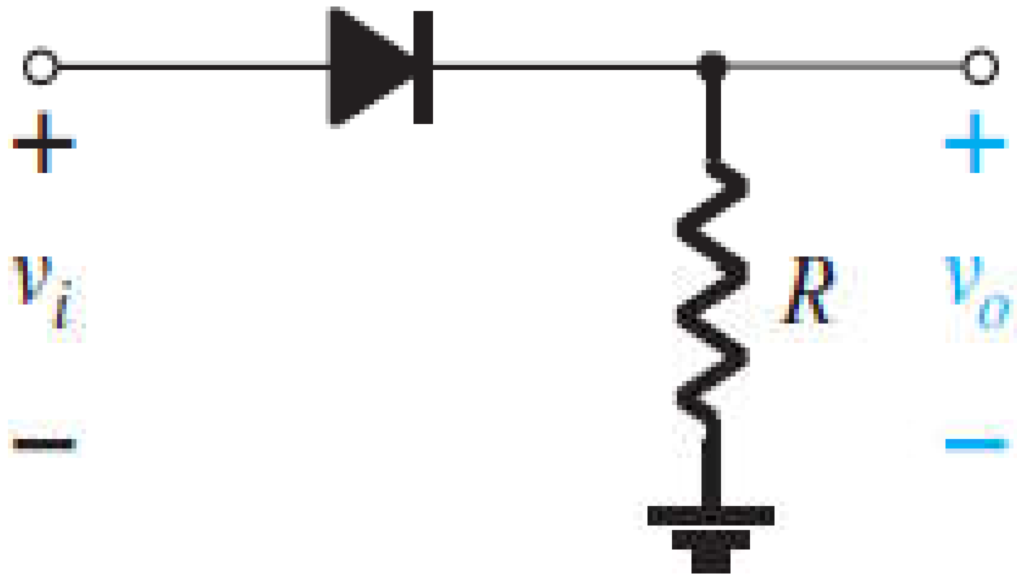
(*iii*)

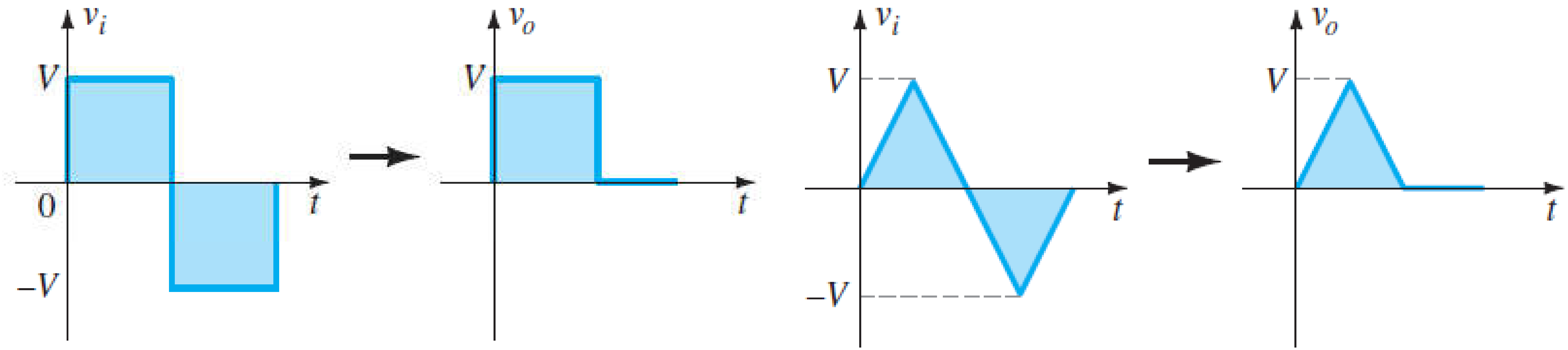


(*iv*)

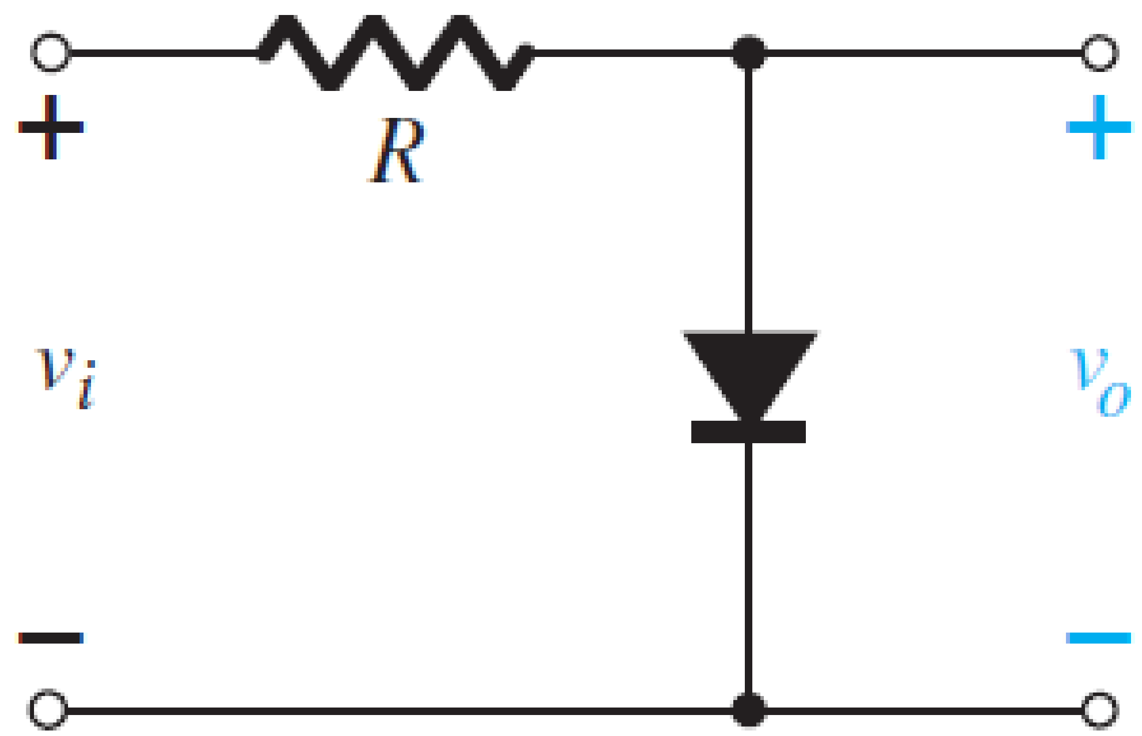
Diode as a Clipper (Series)

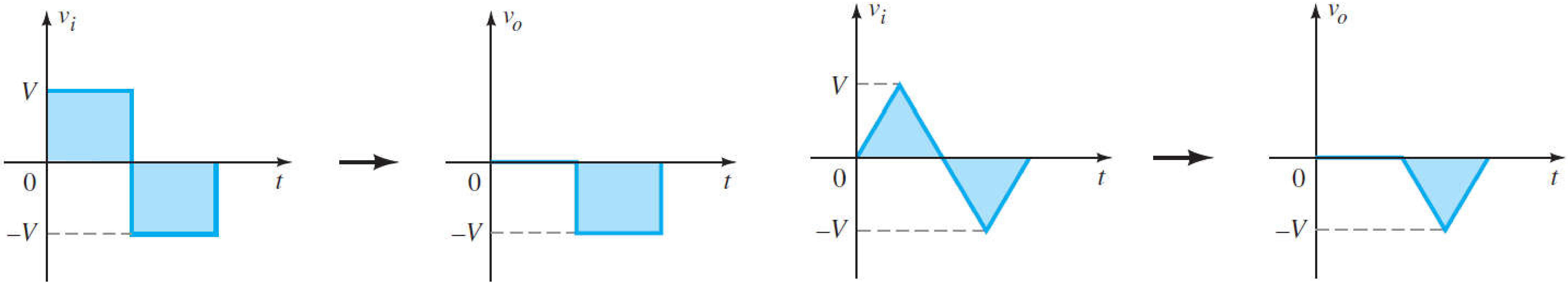
Clipping a portion of an input signal without distorting the remaining part of the waveform



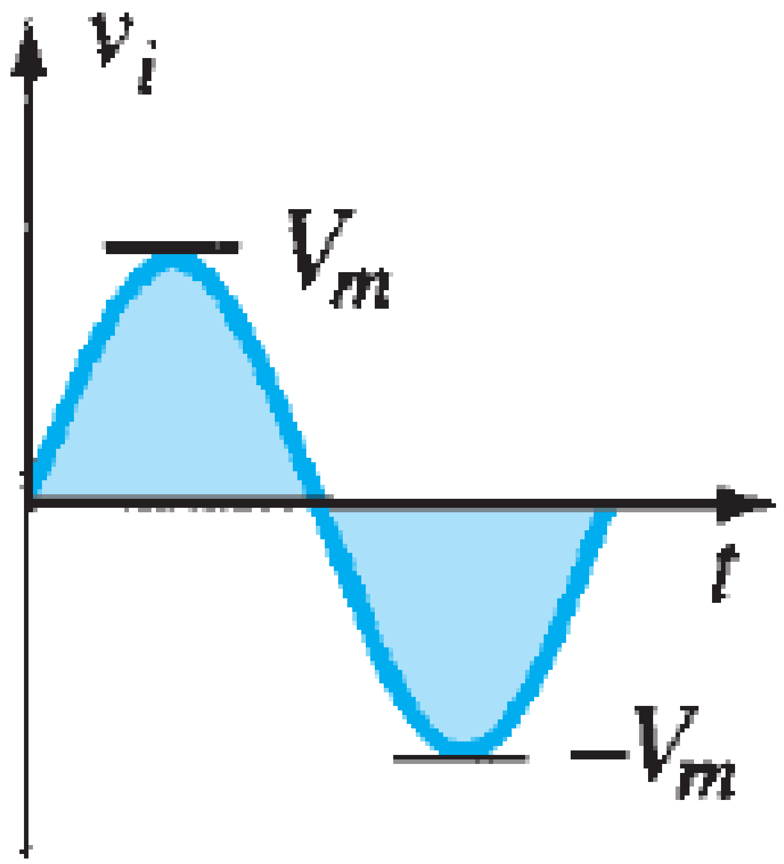


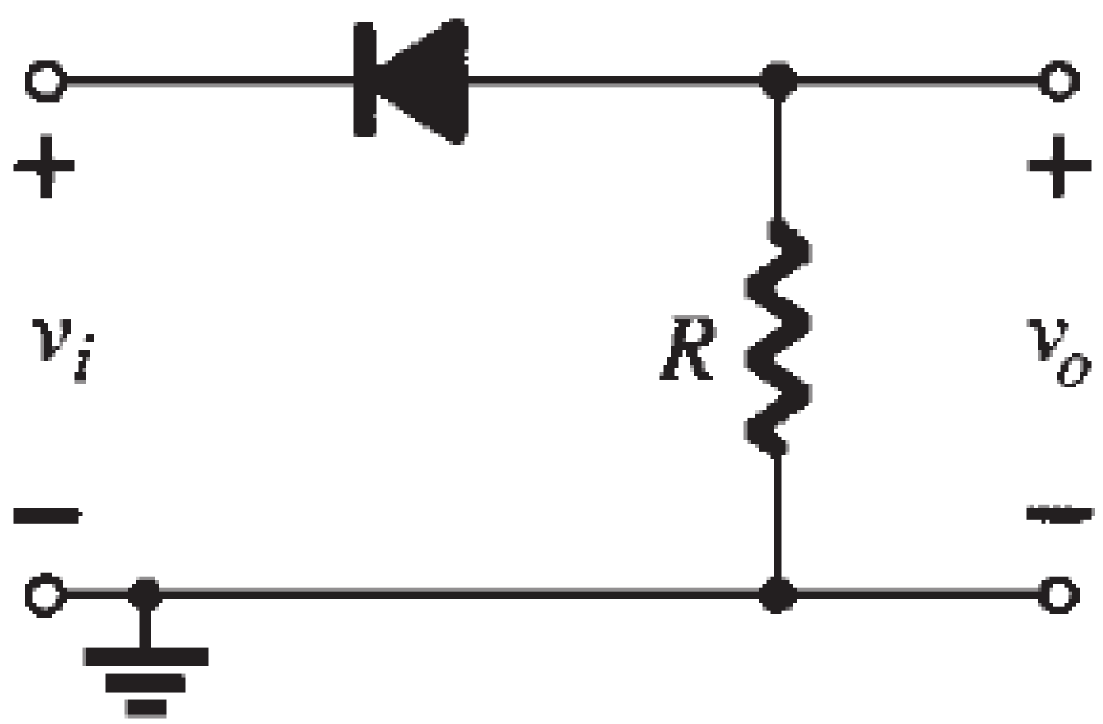
Diode as a Clipper (Parallel)

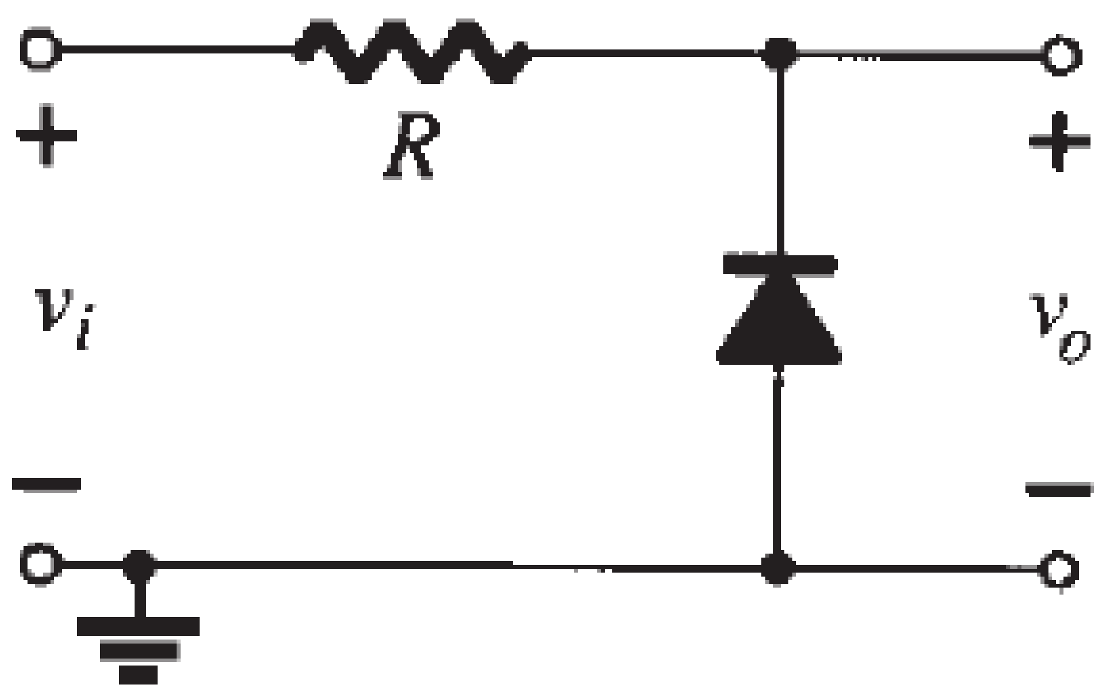




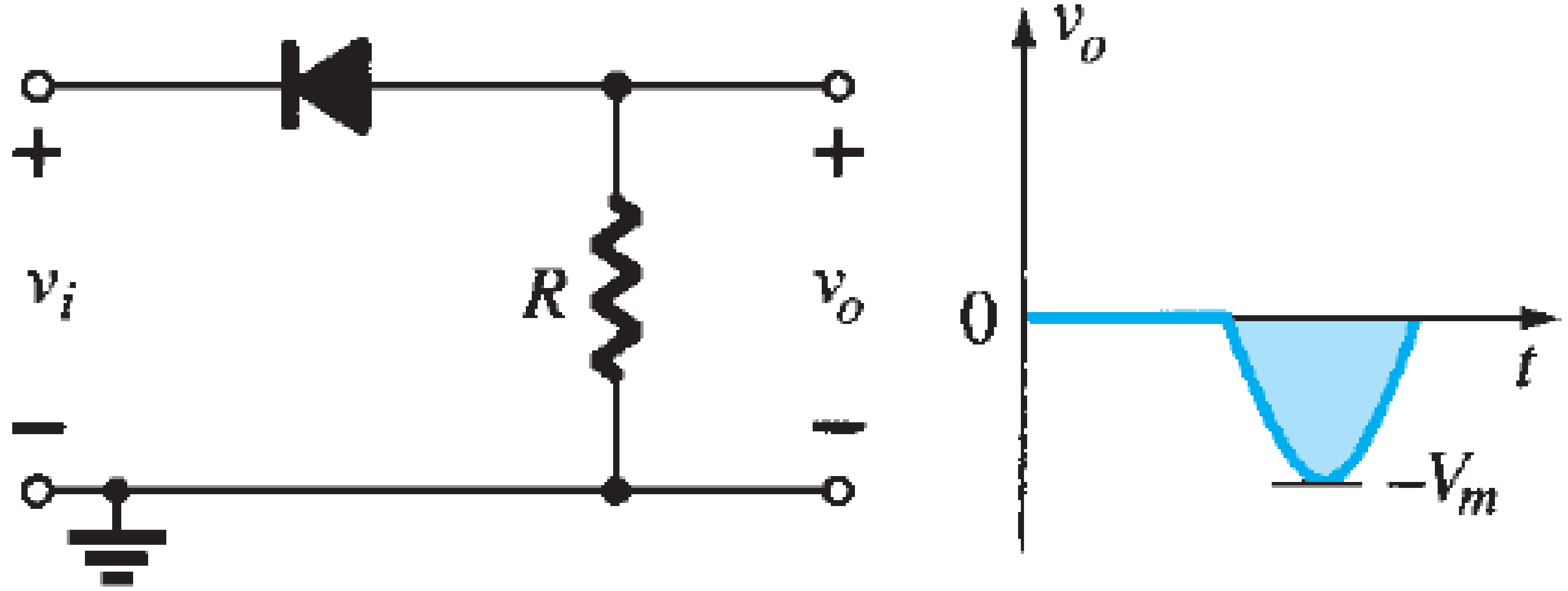
Concept Check…

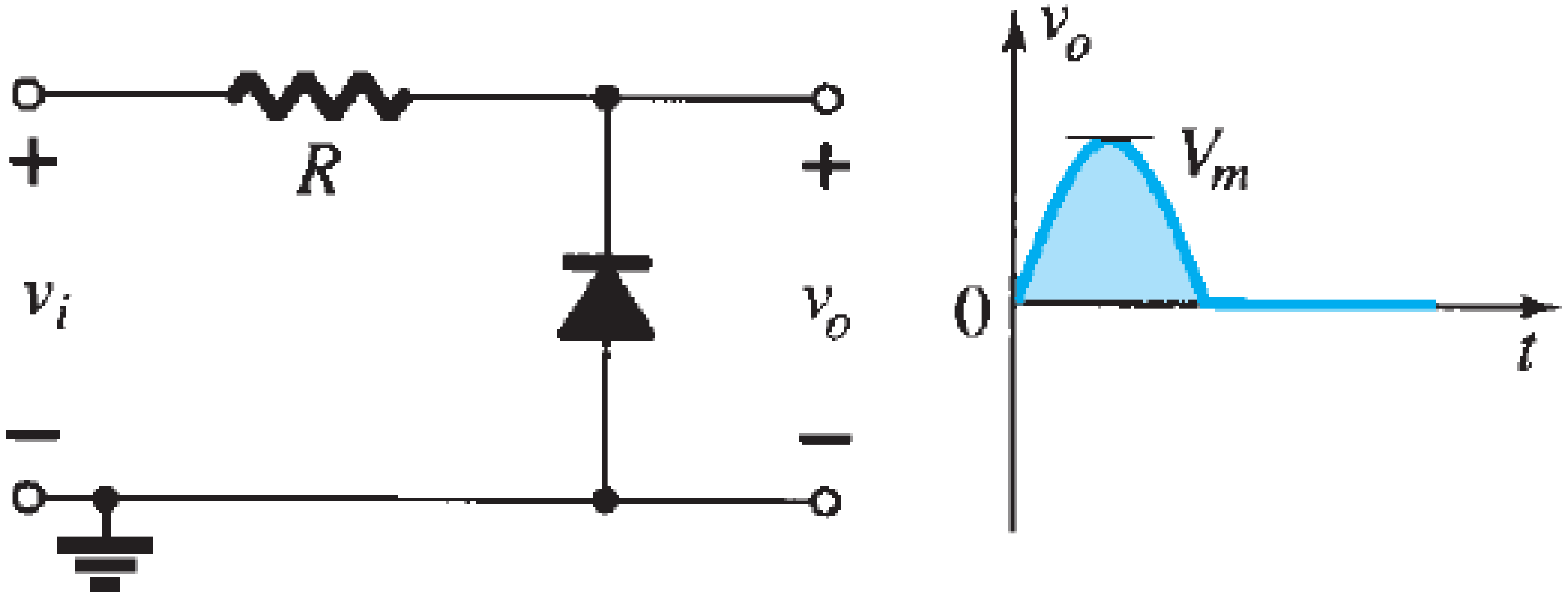






Solution





To Be Continued…