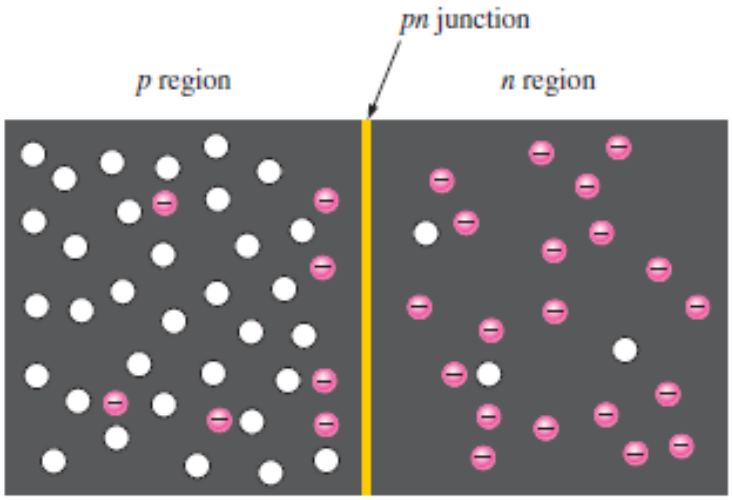
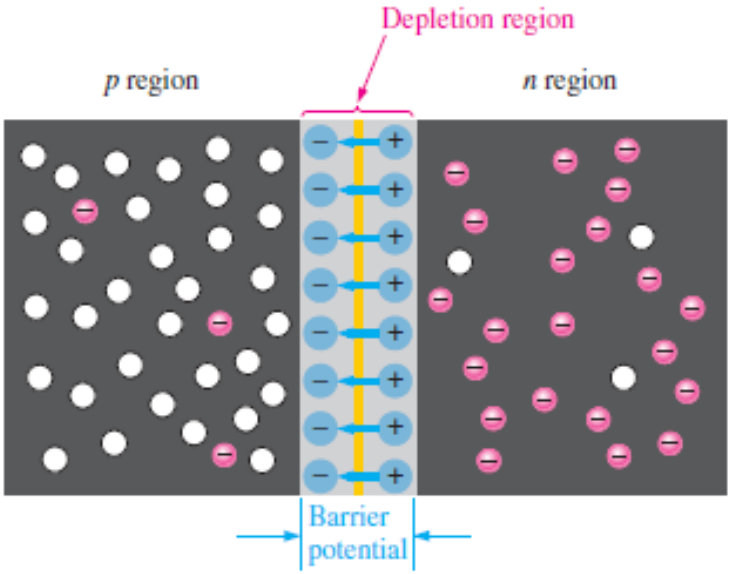
1–5: THE PN JUNCTION

- If a piece of intrinsic silicon is doped so that part is n-type and the other part is p-type, a **pn junction** forms at the boundary and a diode is created.

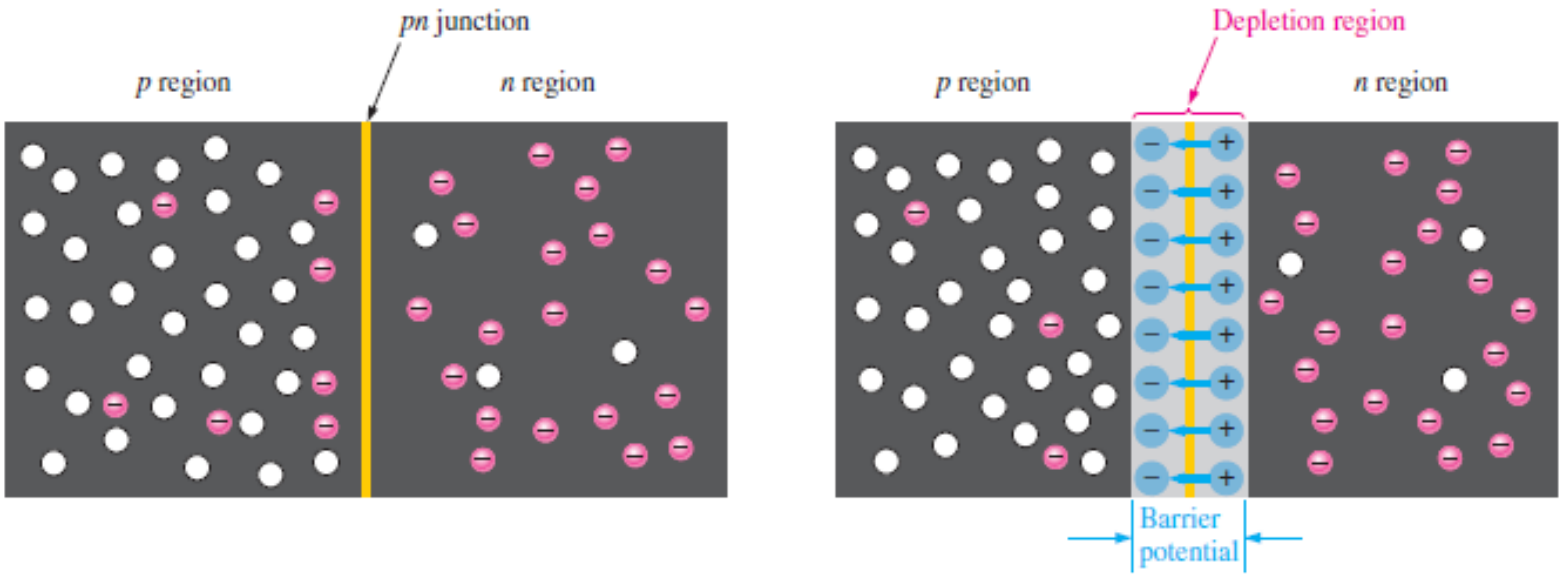


The basic silicon structure at the instant of junction formation showing only the majority and minority carriers. Free electrons in the *n* region near the *pn* junction begin to diffuse across the junction and fall into holes near the junction in the *p* region.



At equilibrium: For every electron that diffuses across the junction and combines with a hole, a positive charge is left in the *n* region and a negative charge is created in the *p* region, forming a **barrier potential**. This action continues until the voltage of the barrier repels further diffusion. The blue arrows between the positive and negative charges in the depletion region represent the electric field.

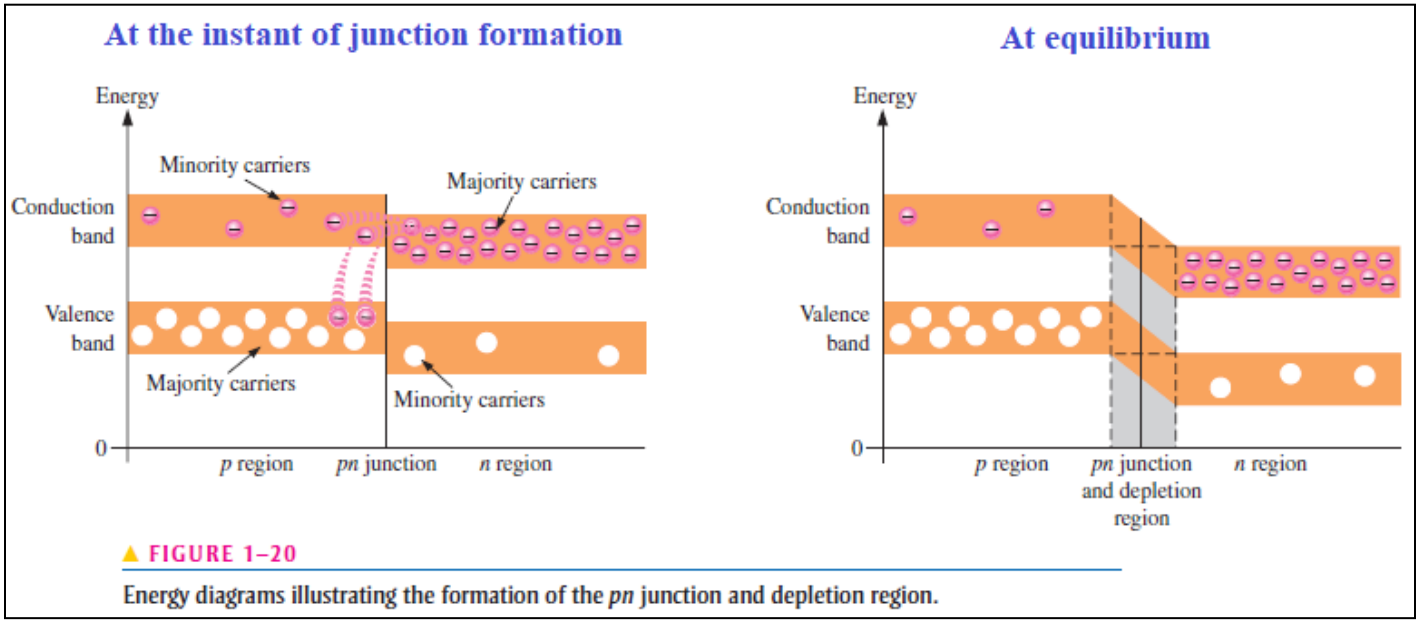
1–5: THE PN JUNCTION



- **Depletion:** the region near the pn junction that is depleted of charge carriers (*e*,*h*). The depletion region expands to a point where equilibrium is established and there is no further diffusion.

- **Barrier Potential**: because forces between the opposite charges form an electric field. This electric field is a barrier to the free electrons in the n region, and energy must be expended to move an electron through the electric field.
- (**Si = 0.7 V** , **Ge= 0.3 V** at T=25 C)

Energy Diagrams of the *PN* Junction and Depletion Region



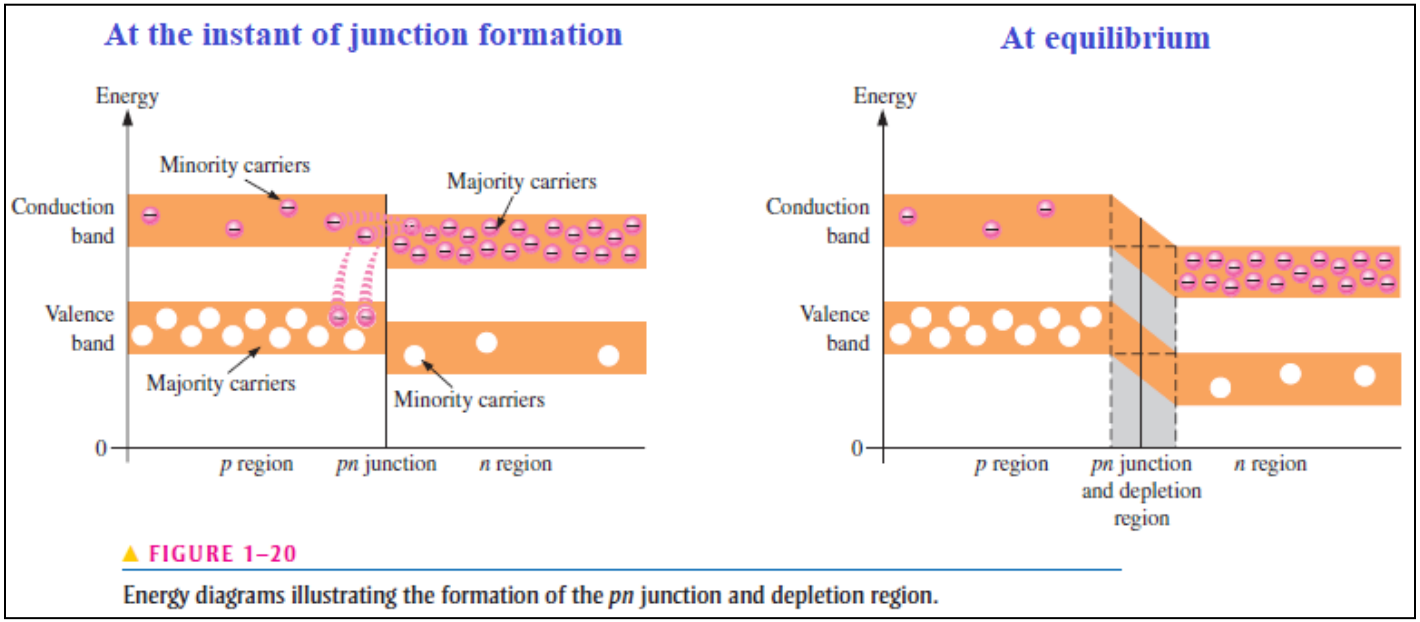
▲ FIGURE 1–20

Energy diagrams illustrating the formation of the *pn* junction and depletion region.

- The n-type valence and conduction bands are at slightly lower energy levels *p*-type material. The trivalent impurities in **p-type** exert **lower forces** on the outer-shell electrons than the Pentavalent impurities in n-type → **electron orbits in p-type has larger energy.**

- Free electrons in the *n* region that occupy the upper part of the conduction band can easily **diffuse across the junction** and temporarily become free electrons in the lower part of the *p*-region conduction band. Then, electrons quickly lose energy and fall into the holes in the *p*-region valence band.

Energy Diagrams of the *PN* Junction and Depletion Region



▲ FIGURE 1–20

Energy diagrams illustrating the formation of the *pn* junction and depletion region.

- As the diffusion continues, the **depletion region begins to form** and the energy level of the *n*-region conduction band decreases due to the loss of the higher-energy electrons that have diffused across the junction to the *p* region.

- Soon, there are no electrons left in the *n*-region conduction band with enough energy to get across the junction to the *p*-region conduction band. At this point, **the junction is at equilibrium**; and the depletion region is complete because diffusion has ended.

- There is an **energy gradient** across the depletion region which acts as an "energy hill" that an *n*-region electron must climb to get to the *p* region.