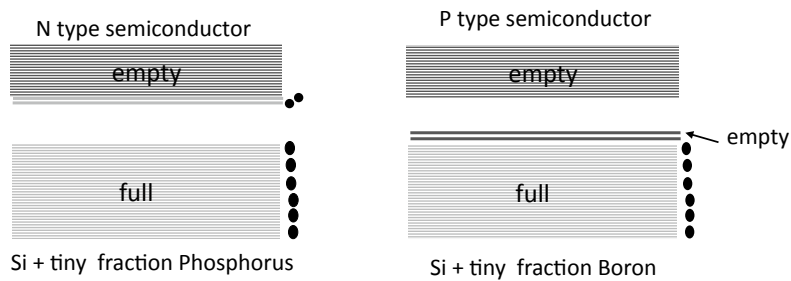


6.1 Ideal pn junction



Extra or missing free/moveable electrons are NOT(!) EXTRA TOTAL CHARGE.
There are also extra or missing protons!
Typically books (and these pictures) just show moveable electrons.

N type- atoms with extra free electrons

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P type semiconductors

"holes", leave room to move

This is standard representation showing only moveable charges,
not actual electric charge. +s are unfilled electron levels!

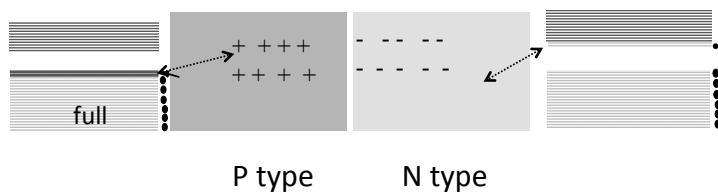
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When semiconductors get really useful:

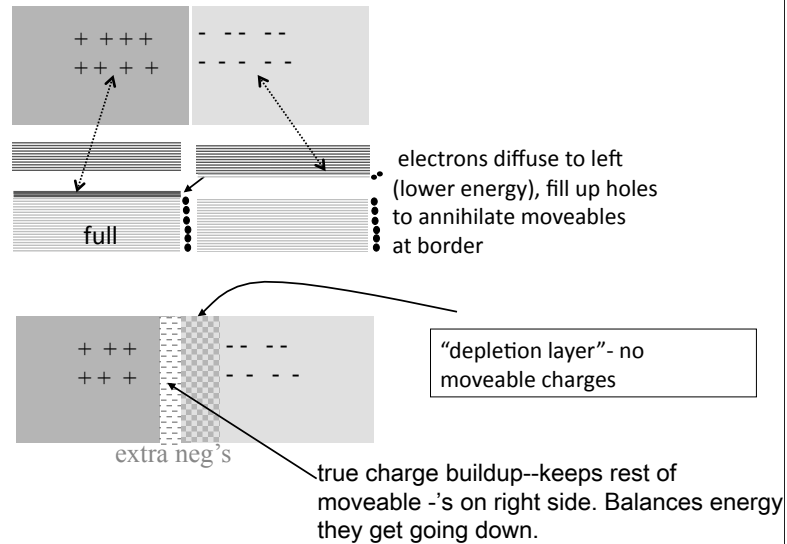
Diodes (& LEDs) - PN junctions.

Transistors- PNP or NPN junctions

PN junction



P- N junction



I. II. III. IV.

Net electrical charge in the regions above is

A. I. +, II. +, III. -, IV. -
 B. I. +, II. 0, III. 0, IV. -
 C. I. 0, II. -, III. +, IV. 0
 D. I. 0, II. 0, III. 0, IV. 0
 E. I. +, II. -, III. +, IV. -

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I. II. III. IV.

Net electrical charge in the regions above is

A. I. +, II. +, III. -, IV. -
 B. I. +, II. 0, III. 0, IV. -
 C. I. 0, II. -, III. +, IV. 0
 D. I. 0, II. 0, III. 0, IV. 0
 E. I. +, II. -, III. +, IV. -

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Properties of the PN junction

(a) Carrier distribution in a PN junction. The p-region (width p) contains acceptor ions B^- and holes h^+ . The n-region (width n) contains donor ions As^+ and electrons e^- . A Metallurgical Junction (M) is shown at the interface.

(b) Neutral p-region and Neutral n-region. The built-in electric field E_o is shown pointing from the n-region to the p-region. The widths of the neutral regions are W_p and W_n .

(d) Net charge density ρ_{net} vs position x . The p-region has a net charge density of $-eN_a$ and the n-region has eN_d . The metallurgical junction (M) is at $x=0$. The widths W_p and W_n are indicated.

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(a) Carrier distribution in a PN junction. The p-region (width p) contains acceptor ions B^- and holes h^+ . The n-region (width n) contains donor ions As^+ and electrons e^- . A Metallurgical Junction (M) is shown at the interface.

(b) Neutral p-region and Neutral n-region. The built-in electric field E_o is shown pointing from the n-region to the p-region. The widths of the neutral regions are W_p and W_n .

If $W_n > W_p$, as in the picture,

A) $N_a = N_d$
 B) $N_a > N_d$
 C) $N_a < N_d$

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(a)

(b)

If $W_n > W_p$, as in the picture,

A) $N_a = N_d$
 B) $N_a > N_d$
 C) $N_a < N_d$

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(e)

(f)

(g)

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Turn on voltage, what happens? (why?)

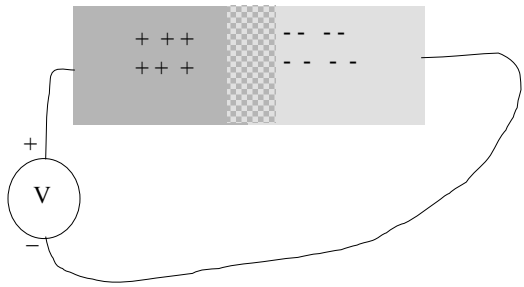
- electrons flow from left to right through junction.
- electrons will not flow.
- electrons will flow from right to left through junction.

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big pile of negative charges, no moveable charges

Both +s and -s pulled away from junction. Depletion region bigger. Current can't flow. ans. b.

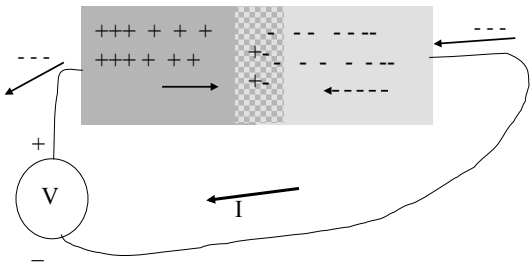
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Turn on opposite voltage, what happens? (why?)

- electrons flow from left to right.
- electrons will not flow
- electrons will flow from right to left

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opposite voltage, what happens?

*holes get shoved into depletion from left,
electrons get shoved into depletion from right,
= no more depletion region
⇒ moveable charges carry current.*

*V has to be bigger than the
electrostatic barrier from charge.*

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So $V >$ electrostatic barrier in one direction, big current.
 V in opposite direction, no current.
Diode is one-way street for current flow.

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diode conducting

As electron moves across junction going from N type on right to P type on left

- it stays at the same energy
- it gains potential energy (if so from where?)
- it loses potential energy (if so to where?)

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diode conducting

c. loses potential energy- goes into 1) heat (vibrating atoms)
or 2) if proper materials, light (light emitting diode)

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LEDs -- don't burn out, high efficiency.

Really good LEDs reach laser conditions-- diode lasers

<http://www.howstuffworks.com/index.htm>

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