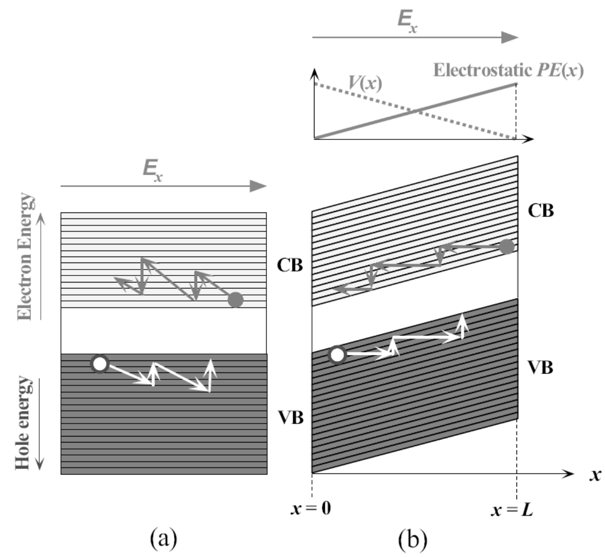
5.1 Intrinsic (pure) and 5.2 Extrinsic (doped) semiconductors

Announcements:

- Errata for Lab
- NO CLASS: Friday 4/29



The conductivity of metals decreases with increasing temperature due to electron collisions with vibrating atoms. In contrast, the conductivity of semiconductors increases with increasing temperature. What property of a semiconductor is responsible for this behavior?

A. Atomic vibrations decrease as temperature increases.
B. The number of conduction electrons and the number of holes increase steeply with increasing temperature.
C. The energy gap decreases with increasing temperature.
D. Electrons do not collide with atoms in a semiconductor.

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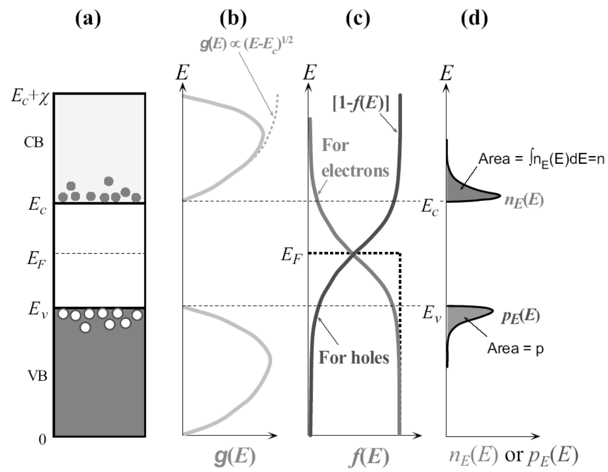
All materials obey Ohm's Law:

A. True
B. False



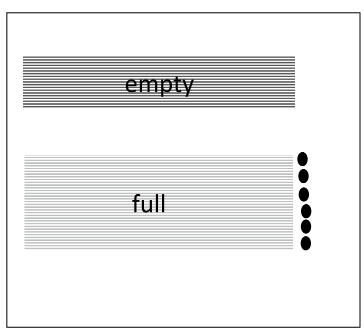
How do we calculate n and p?

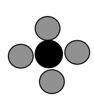
Boltzmann ~ $e^{-E/kT}$, but n_i ~ $e^{-Egap/2kT}$, where does the 2 come from?

A. electrons fill up half the gap when they go up to the conduction band
B. whenever an electron is promoted to the conduction band a hole is created in the valence band
C. magic!

5.2 Extrinsic (doped) semiconductors

Pure semiconductor (Si):

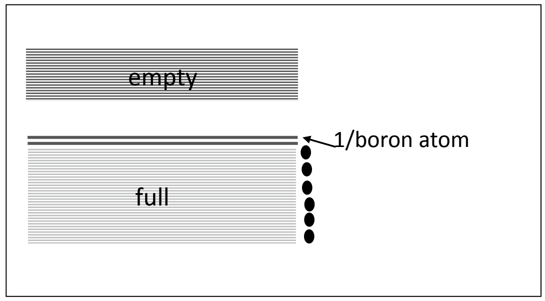


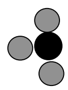


4 electrons in valence band

P-type semiconductor (Si with B impurities):

Si + 10^{-7} boron

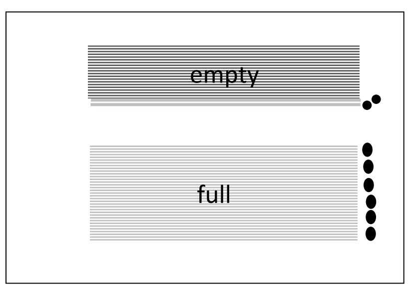


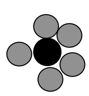


B: 3 electrons into valence band

N-type semiconductor (Si with P impurities):

Si + 10^{-7} Phosphorus





P (5 valence electrons): 4 electrons into Si valence band, 1 extra up into conduction

How does the conduction of a pure semiconductor, a P-type semiconductor and an N-type semiconductor compare?

A. all ~same.
B. pure best,
C. pure no, P and N ~same,
D. only N conducts

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Answer: C. N and P type both conduct ok (not great), pure Si does not conduct.

In general, how does the conduction of a P-type semiconductor and an N-type semiconductor compare?

A. They are equal
B. P type is a better conductor,
C. N type is a better conductor

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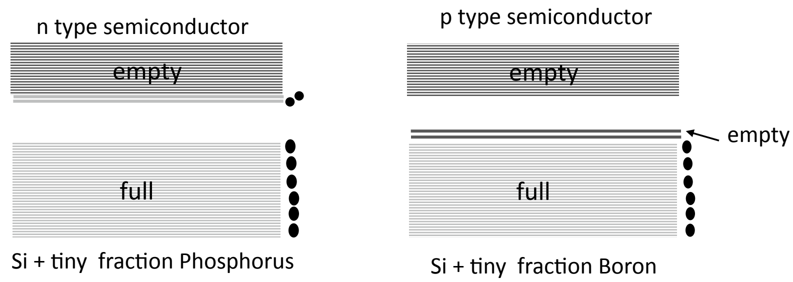
Answer: C. N conducts better since typically $\mu_e > \mu_h$



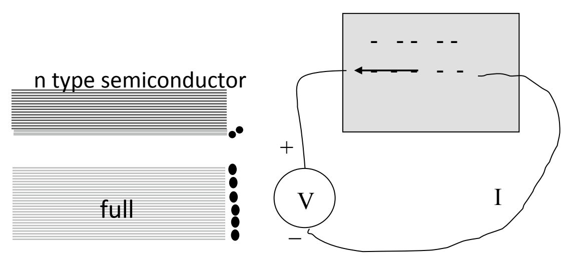
n- electrons in conduction (top) band can move.

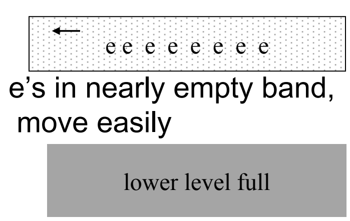
p- electrons at top of valence band move into empty levels.

DOPING--EXTRA OR MISSING FREE/MOVEABLE ELECTONS, IS NOT(!) EXTRA TOTAL CHARGE. THERE ARE ALSO EXTRA OR MISSING PROTONS!

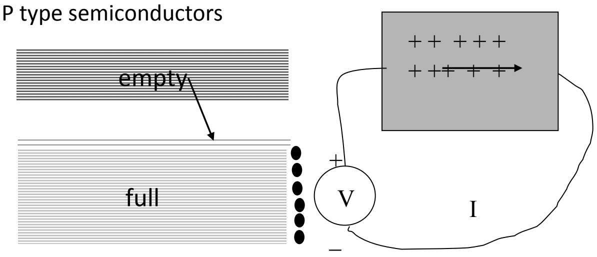
These pictures SHOW MOVEABLE ELECTRONS only!

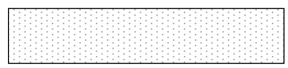
N type- atoms with extra free electrons



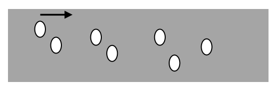


P type semiconductors





electrons missing, “holes”, leave room to move



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