Class #24
Bonding in Solids: Semiconductors

CHEM 107
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Band Diagrams

Metal

Semiconductor

Insulator
Semiconductors

- Band gaps:
  - diamond: 580 kJ/mol
  - silicon: 105 kJ/mol
  - germanium: 64 kJ/mol
- Pure Si or Ge conduct well at high T or if exposed to light. Why would that increase conductivity?

Semiconductors

- Energy from heat, light, etc.
- With electrons promoted, material begins to conduct
Doped Semiconductors

- Pure elemental (Si, Ge, etc.) semiconductors only useful where light or heat can be supplied to promote electrons
- More useful devices are made using “doped” semiconductors

n-Type Semiconductors

- Initially, valence band full, conduction band empty
- Added e⁻ must go into conduction band
n-Type Semiconductors

• Added electron(s) can be promoted easily, so can serve as charge carriers
• How can we add extra electrons to Si?

n-Type doping

• “Dope” with phosphorous (or another element with more valence e’s)
• Typical n-type devices contain on the order of 0.00001% dopant
• Energy levels for dopant atom will be slightly different than for the silicon.
n-Type Semiconductors

- In a real material, we can’t add just one electron
- Extent of conductivity depends on # of e⁻'s added

p-Type Semiconductors

- Initially, valence band full, conduction band empty

Removing an e⁻ creates a “hole” in valence band
p-Type Semiconductors

- Holes allow promotion of electrons within the valence band, so they serve as charge carriers
- How can we remove electrons from Si?

“Dope” with aluminum
Small, controllable doping levels, similar to n-type

p-Type Semiconductors

- As for n-type, can’t really remove just one e⁻
- Extent of doping determines conductivity
Semiconductor Devices

- Properties of n & p type differ slightly. Most real devices contain combinations of the two.
- Most important circuit functions are controlled by “junctions” where n & p type materials meet.

**p-n Junction**

Apply voltage - current flows.
p-n Junction

Opposite voltage - no current

p-type material

n-type material