Worksheet 7: Semiconductors and Band Gaps

Other questions: 11.115, 11.117, 11.133, 11.137

1. What temperature must you raise a semiconductor material to in order to move electrons if the band gap is Eg = 0.9 eV?
2. How thin must a semiconducting material with a band gap of 1.2 eV be in order for 120 V to supply sufficient energy to move electrons from the valence band to the conduction band?
3. Is visible light with wavelength of 575 nm sufficient to move electrons in a metal? An insulator? A semiconductor?
4. How does the electron-sea model account for the malleability and ductility of metals?
5. Cesium metal is very soft, and tungsten metal is very hard. Explain the difference using the electron-sea model.
6. Explain why germanium doped with phosphorus has a higher electrical conductivity than pure germanium.
7. Classify the following semiconductors as *n*-type or *p*-type:
   a. Si doped with In b. Ge doped with Sb c. Sn doped with As
8. Gallium arsenide, a material used to manufacture laser printers and compact-disc players, has a band gap of 130 kJ/mole. Is GaAs a conductor, semiconductor, or insulator? With what group 4A element is GaAs isoelectronic?
9. What is the wavelength of light emitted by an aluminum arsenide laser with a band gap of 2.15 eV?
10. The series of nitride ceramics, AlN, GaN, and InN are all semiconductors used in the microelectronics industry. The band gaps for these three compounds are 192.9, 322.1 and 580.6 kJ/mole. Which band gap goes with which semiconductor and why? Which, if any, of these energies correspond to radiation in the visible region of the spectrum?

Key:

1. 1.0×10^4 K 2. 2.0×10^{-4} cm 3. Yes, no, yes

4. When a metallic crystal is deformed, no localized bonds are broken. Instead, the electron sea simply adjusts to the new distribution of cations and the energy of the deformed structure is similar to that of the original. Thus, the energy required to deform a metal is relatively small.

5. The energy required to deform a transition metal like W is greater than that for Cs because W has more valence electrons and hence more electrostatic "glue".

6. The extra electrons of the doped Ge lie in the "extra" energy levels near the conduction band. Therefore the "new" band gap is smaller in the doped Ge than in pure Ge.

7. p, n, n 8. semi, Ge 9. 577 nm

10. AlN: 580.6; GaN: 322.1; InN: 192.9; The smaller the atom, the more the orbitals overlap, resulting in a bigger band gap. InN