P1

Consider Lithium atonm, which has an atomic number $Z = 3$. The three electrons in a lithium aton occupy orbitals in increasing energy levels. Describe the arrangement of there three electrons in term of their quantum number n, l, m_l, m_s, based on the Pauli exclusion principle.

- first electron: $\{n, l, m_l, m_s\} = \{1, 0, 0, \frac{1}{2}\}$;
- second electron: $\{n, l, m_l, m_s\} = \{1, 0, 0, -\frac{1}{2}\}$;
- third electron: $\{n, l, m_l, m_s\} = \{2, 0, 0, \frac{1}{2}\}$;

P2 (10-27)

- a. The energy gap between the valence band and the conduction band in silicon is 1.14eV. at room temperature. What s the wavelength of a photon that will excite an electron from the top of the valence band to the bottom of the conduction band?
- b. Do the same calculation for Germanium, for which the energy gap is 0.72 eV.
- c. Do the same calculation for Diamond, for which the energy gap is 7.0 eV.

Using $E = h\frac{c}{\lambda} \Rightarrow \lambda = h\frac{c}{E}$:

- a.
$$\lambda = \frac{1240eV\ \text{nm}}{1.14eV} = 1.09e\text{-}6m; \tag{1}$$
- b.
$$\lambda = \frac{1240eV\ \text{nm}}{0.72eV} = 1.72e\text{-}6m; \tag{2}$$
- c.
$$\lambda = \frac{1240eV\ \text{nm}}{7.0eV} = 1.77e\text{-}7m \tag{3}$$

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3. (10.28)

- a. The energy band gap in Germainium is 0.72 eV. What wavelength range of visible light will be transmitted by a germanium crystal? (think about it carefully!)
- b. Now consider a crystal of of an insulator whose energy band gap is 3.6 eV. What wavelength range of visible light will this crystal transmit?
- c. Justify your answers to part a,b.

- a. As visible light spectrum is from 380 nm to 720 nm, which is above 172nm as previously calculated, a germanius crystal will tabsorbs all visible light and transmit none.
- b.
$$\lambda = \frac{1240eV\ \text{nm}}{3.6eV} = 3.44e\text{-}7m = 344\ \text{nm} \tag{4}$$

  this is below 380 nm, so the crystal will transmit all visible light and absorb none.

4.

For energies ranging from $E_f - 0.2$eV to $E_f + 0.2$eV, **plot the Fermi distribution function for each of the following temperatures: $4K, 77K, 300K$**. Hand plot all 3 curves on one graph. (These 3 temperatures are important benchmarks in experiments, as 300 K is room temperature, 77 K is the temperature to which you can cool with liquid nitrogen and 4 K is the temperature to which you can cool with liquid helium))

Using the formula for fermi distribution:

$$f_{\mathrm{FD}}(E) = \frac{1}{E^{(E-E_f)/(kT)} + 1} \tag{5}$$

and ploting the graph for $E_f \in [-0.2, +0.2]$eV, and for $T \in \{4, 77, 300\}K$, we have the following graph.