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

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.

- c. I am not sure what there is to be justified as my answers are based on the calculation of the wavelength of the light, and the wavelength of the light is the only factor that determines whether the light will be absorbed or transmitted.

4.

For energies ranging from $E_f - 0.2\text{eV}$ to $E_f + 0.2\text{eV}$, **plot the Fermi distribution function for each of the following temperatures: $\boldsymbol{4K, 77K, 300K}$**. 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:

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

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