

VE320 Homework 2

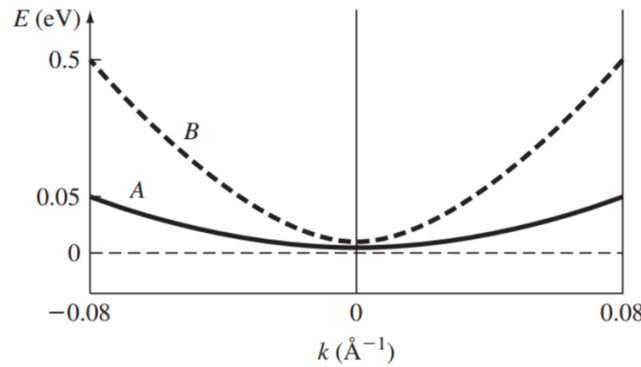
Due: 29/05/2019 10:00 am

- The bandgap energy in a semiconductor is usually a slight function of temperature. In some cases, the bandgap energy versus temperature can be modeled by

$$E_g = E_g(0) - \frac{\alpha T^2}{\beta + T}$$

where $E_g(0)$ is the value of the bandgap energy at $T = 0K$. For silicon, the parameter values are $E_g(0) = 1.170eV$, $\alpha = 4.73 \times 10^{-4}eV/K$, and $\beta = 636K$. Plot E_g versus T over the range $0 \leq T \leq 600K$. In particular, note the value at $T = 300K$.

- The figure below shows the parabolic E versus k relationship in the conduction band for an electron in two particular semiconductor materials, A and B. determine the effective mass (in units of the free electron mass) of the two electrons.



- For silicon, find the ratio of the density of states in the conduction band at $E = E_c + kT$ to the density of states in the valence band at $E = E_v - kT$.
 - Repeat part (a) for GaAs.
- Determine the probability that an energy level is empty of an electron if the state is below the Fermi level by (a) kT , (b) $5kT$, and (c) $10kT$.
- The Fermi energy in silicon is $0.30eV$ below the conduction band energy E_c at $T = 300K$. Plot the probability of a state being occupied by an electron in the conduction band over the range $E_c \leq E \leq E_c + 2kT$.
 - The Fermi energy in silicon is $0.25eV$ above the valence band energy E_v . Plot the probability of a state being empty by an electron in the valence band over the range $E_v - 2kT \leq E \leq E_v$.
- The probability that a state at $E_c + kT$ is occupied by an electron is equal to the probability that a state at $E_v - kT$ is empty. Determine the position of the Fermi

energy level as a function of E_c and E_v .

7. (a) Calculate the temperature at which there is a 10^{-8} probability that an energy state 0.60eV above the Fermi energy level is occupied by an electron.
(b) Repeat part (a) for a probability of 10^{-6} .