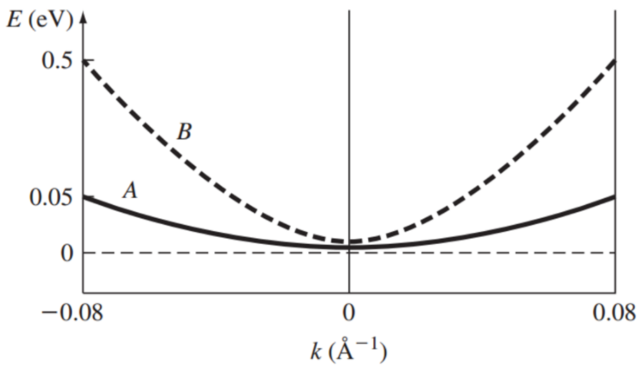
VE320 Homework 2

Due: 29/05/2019 10:00 am

1. 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 $T = 300K$.

2. 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.



3. (a) 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 $E = E_v - kT$.
(b) Repeat part (a) for GaAs.

4. 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)$10kT$.

5. (a) 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 $E_c \leq E \leq E_c + 2kT$.
(b) 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 $E_v - 2kT \leq E \leq E_v$.

6. 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}.