ELEC 321/4-H	INTRODUCTION TO SEMICONDUCTOR MATERIALS AND DEVICES	Winter 2018

Homework due on February 6th 2018
No late homework will be accepted

Homework #2

1. The average energy of an electron in an electron gas at thermal equilibrium is $3K_BT/2$ (K_B is the Boltzmann constant). Determine, for room temperature (i.e. T = 300 K), liquid Nitrogen's temperature (i.e. T=80 K), and liquid Helium's temperature (i.e., T=4.2 K), the average electron energy (in eV), average electron momentum, and the de Broglie wave length.
2. An electron and a photon have the same energy. At what value of energy (in eV) will the wavelength of the photon be ten times that of the electron?
3. The solution to the time independent Schrödinger wave equation for a particular situation is given by $\psi(x) = \sqrt{2/a_0}\ \exp(-\frac{x}{a_0})$. (a) Based on the available information what would be the wave function for this particle? (b) Determine the probability of finding the particle in $0 \le x \le \frac{a_0}{4}$ interval.
4. A one-dimensional infinite potential well with a width of 12 Å contains an electron. (a) Calculate the first two energy levels that the electron may occupy. (b) If an electron drops from the second energy level to the first, what is the wavelength of a photon that might be emitted?
5. Consider a three-dimensional infinite potential well. The potential function is given by $V(x) = 0$ for $0<x<a$, $0<y<a$, $0<z<a$, and $V(x) = \infty$ elsewhere. Start with Schrödinger's wave equation, use the separation of variables technique, and show that the energy is quantized and is given by
$$E_{n_x n_y n_z} = \frac{\hbar^2\pi^2}{2ma^2}\left(n_x^2 + n_y^2 + n_z^2\right)$$
where $n_x = 1,2,3,\ldots$, $n_y = 1,2,3,\ldots$, $n_z = 1,2,3,\ldots$
Hint: Assume the electron mass to be the same along all three directions.
6. (a) Estimate the tunneling probability of a particle with an effective mass of $0.067m_0$ (an electron in Gallium Arsenide), where m_0 is the mass of an electron, tunneling through a rectangular potential barrier of height V_0 = 0.8 eV and width 15 Å. The particle kinetic energy is 0.20 eV. (b) Repeat part (a) if the effective mass of the particle is 1.08 m_0 (an electron in silicon).