VE320 Homework One

Due: 2021/5/21 23:59

1. The lattice constant of a simple cubic lattice is a_0.
   a) Sketch the following planes: (i) (110), (ii) (111), (iii) (220), and (iv) (321).
   b) Sketch the following directions: (i) $[110]$, (ii) $[111]$, (iii) $[220]$, and (iv) $[321]$.

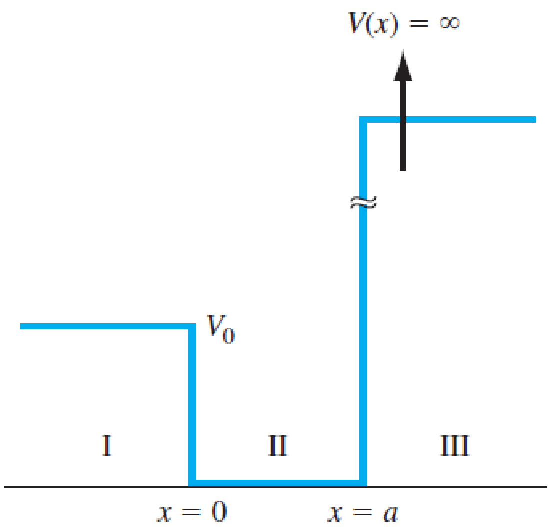
2. The lattice constant of a single crystal is 4.73 Å. Calculate the surface density $(\#/cm^2)$ of atoms on the (i) (100), (ii) (110), and (iii) (111) plane for a (a) simple cubic, (b) body-centered cubic, and (c) face-centered cubic lattice.

3. The work function of a material refers to the minimum energy required to remove an electron from the material. Assume that the work function of gold is $4.90\ eV$ and that of cesium is $1.90\ eV$. Calculate the maximum wavelength of light for the photoelectric emission of electrons for gold and cesium.

4. According to classical physics, the average energy of an electron in an electron gas at thermal equilibrium is $3kT/2$. Determine, for $T = 300\ K$, the average electron energy (in eV), average electron momentum, and the de Broglie wavelength.

5. Assume that $\Psi_1(x,t)$ and $\Psi_2(x,t)$ are solutions of the one-dimensional time-dependent Schrodinger's wave equation. (a) Show that $\Psi_1 + \Psi_2$ is a solution. (b) Is $\Psi_1 \cdot \Psi_2$ a solution of the Schrodinger's equation in general? Why or why not?

6. Consider the one-dimensional potential function shown in the figure below. Assume the total energy of an electron is $E < V_0$
   a) Write the wave solutions that apply in each region.
   b) Write the set of equations that result from applying the boundary conditions.
   c) Show explicitly why, or why not, the energy levels of the electron are quantized.



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

8. Figure below shows the parabolic E versus k relationship in the valence band for a hole in two particular semiconductor materials. Determine the effective mass (in units of the free electron mass) of the two holes.