VE320 Homework 1

1. 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.

2. 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.

3. (*a*) The de Broglie wavelength of an electron is 85 Å. Determine the electron energy (eV), momentum, and velocity. (*b*) An electron is moving with a velocity of 8×10^5 cm/s. Determine the electron energy (eV), momentum, and de Broglie wavelength (in Å).

4. Consider the wave function $\Psi(x, t) = A\left(\cos\left(\frac{\pi x}{2}\right)\right) e^{-j\omega t}$ for $-1 \leq x \leq +3$. Determine A so that $\int_{-1}^{+3} |\Psi(x, t)|^2 dx = 1$.

5. (*a*) An electron in free space is described by a plane wave given by $\Psi(x, t) = Ae^{j(kx-\omega t)}$. If $k = 8 \times 10^8\ m^{-1}$ and ω 8×10^{12} rad/s, determine the (*i*) phase velocity and wavelength of the plane wave, and the (*ii*) momentum and kinetic energy (in eV) of the electron. (*b*) Repeat part (*a*) for $k = -1.5 \times 10^9\ \text{m}^{-1}$ and $\omega = 1.5 \times 10^{13}$ rad/s.

6. An electron is bound in a one-dimensional infinite potential well with a width of 10 Å. (*a*) Calculate the first three energy levels that the electron may occupy. (*b*) If the electron drops from the third to the second energy level, what is the wavelength of a photon that might be emitted?

7. A potential function is shown in Figure P2.39 with incident particles coming from $-\infty$ with a total energy $E > V_2$. The constants k are defined as

$$k_1 = \sqrt{\frac{2mE}{\hbar^2}} \qquad k_2 = \sqrt{\frac{2m}{\hbar^2}(E - V_1)} \qquad k_3 = \sqrt{\frac{2m}{\hbar^2}(E - V_2)}$$

Assume a special case for which $k_2 a = 2n\pi$, $n = 1, 2, 3, \ldots$. Derive the expression, in terms of the constants, k_1, k_2, and k_3, for the transmission coefficient. The transmission coefficient is defined as the ratio of the flux of particles in region III to the incident flux in region I.

8. Consider the one-dimensional potential function shown in Figure P2.40. 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.

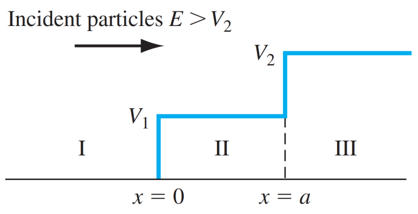

Figure P2.39

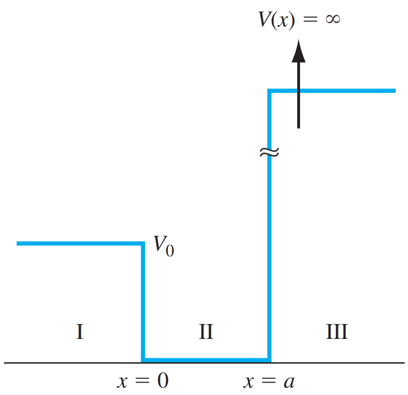

Figure P2.40