NO Solution

Physics 213

Date : 11/08/2004
Time : 120 min

I – (10 %)
Show that the uncertainty relation can also be written: $\Delta x\,\Delta\lambda \geq \lambda^2/4\pi$.

II – (10 %)
Show that, in general, the de Broglie wavelength of a particle of rest mass m_0 and kinetic energy E_k is given by

$$\lambda = \frac{hc}{E_k(1 + 2m_0c^2/E_k)^{1/2}}$$

III – (20 %)
An electron is confined to a one-dimensional infinite potential well of width a = 1.0 nm.

1. Calculate the energies of the ground state and the first two excited states and sketch the wave functions for these states of energy
2. Calculate the probability that the electron will be found in the region 0 < x < 0.25 nm for the ground state and for the first excited state.
3. How do these results compare with the classical prediction?

IV – (10 %)
An electron of kinetic energy E = 5.0 eV is incident on a potential barrier of height 5.5 eV and width 10^{-8} m. Estimate the probability that this electron will tunnel through the potential barrier.

V – (10 %)
Suppose that the force of attraction between a proton and an electron were proportional to r rather than $1/r^2$; that is, $F = -kr$. Use the angular momentum quantization condition to show that the stationary-state radii are given by $r_n = \left(n\hbar/\sqrt{km}\right)^{1/2}$ and that the stationary-state energies are $En = n\hbar\omega$, where ω is the angular frequency of revolution of the particle of mass m in this central force field.

VI – (10 %)
A 50,000-V X-ray tube carries a current of 5.0 mA. Assuming that only 1 percent of the energy of the electron beam is converted to X rays, and that the average energy of the X rays produced is 0.75 of the maximum X-ray energy, determine

1. the number of X-ray photons emitted per second;
2. the amount of heat that must be removed from the anode to keep it from becoming excessively hot.

VII – (10 %)

1. In the Bohr model of the hydrogen atom the electron circulates about the proton. Determine the frequency of revolution of the electron (number of revolutions per second) in the ground state, n = 1, and in the excited state, n = 3.
2. Determine the wavelength of the radiation emitted during a Lyman β transition

VIII – (20 %)
A monochromatic light beam of wavelength $\lambda = 0.55$ µm falls on the cathode of a cesium photoelectric cell. The photoelectric threshold for cesium is $\lambda_0 = 0.66$ µm.

1. Determine the work function W_0 for the cesium cathode.
2. Determine the energy provided by an incident photon.
3. Determine the kinetic energy an electron emitted by the cathode might have. Use it to deduce the initial velocity of the electron.
4. How many electrons must be emitted by the cathode in one second to obtain an electric current intensity of I = 40 µA?
5. To increase the intensity of the current, must we change the frequency or the number of the incident photons per second? Explain and specify the direction of this change (increase or decrease).