THE OPEN UNIVERSITY OF SRI LANKA

B.Sc. DEGREE PROGRAMME 2008/2009

FINAL EXAMINATION 2008

PHU 3142 / PHE 4142 PHYSICAL BASIS OF QUANTUM THEORY, THEORY OF RELATIVITY AND SOLID STATE PHYSICS

DURATION : TWO & HALF HOURS (2 1/2 HR)

Date : 18 – 12 – 2008 **Time : 1.00 pm – 3.30 pm**

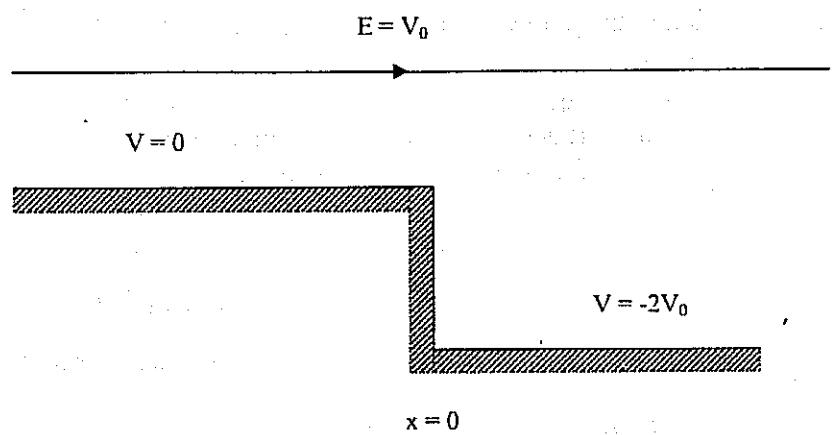
($m_e = 9.11 \times 10^{-31}$ kg, $e = -1.6 \times 10^{-19}$ C, $h = 6.63 \times 10^{-34}$ Js, $c = 3 \times 10^8$ m/s)

Answer **FOUR** Questions

1.(a) Show by analyzing a collision between a photon and a free electron that it is impossible for a photon to transfer to all its energy to a free electron (thus for the photon to vanish)
Through what angle must a 200 keV photon be scattered by a free electron so that the photon losses 10% of its energy?

(b) The hydrogen atom has a radius of about 52.9 pm. Assume that the position uncertainty of the electron in a hydrogen atom does not exceed this figure find the momentum uncertainty of the electron. Estimate the magnitude of the kinetic energy of the electron

2.



Particles of energy $E = V_0$ are incident from the left on a potential energy step of magnitude $2V_0$ as shown in the figure.

(i) Write the Schrodinger equation for the two regions

(ii) Solve the Schrodinger equations and find the wave function in two regions.

(iii) Show that the fraction of particles reflected by the step is 0.0718

3. State the Lorentz inverse transformation equations

(a) The mean lifetime of stationary muons is measured to be 2.2 μs. The mean lifetime of high speed muons in a burst of cosmic rays observed from earth is measured to be 16 μs. Find the speed of these cosmic ray muons relative to earth. Prove any formula you may use.

(b) A passenger in a rocket which is moving away with a speed of 0.8c relative to the earth measured the length of the rocket as 40 m. A light signal is sent from the back of the rocket to the front of the rocket. Determine,
(i) the time taken by the signal to go from the back to the front of the rocket as measured by the passenger and a person on earth, respectively and
(ii) the distance of travel of the signal as measured by the earth observer.

4. Using the formula $m = m_0\gamma$ where $\gamma = \dfrac{1}{\sqrt{1-(v/c)^2}}$ establish the relationship $E^2 = p^2c^2 + m_0^2c^4$, where symbols have their usual meaning. Show also that $2Kc^2m = (pc)^2 - K^2$, where K is the kinetic energy of the particle

The average lifetime of muons at rest is 2.2 μs. A laboratory measurement on muons traveling in a beam entering from a particle accelerator yields an average muon lifetime of 6.9 μs. What are
(i) the speed of these muons in the laboratory and
(ii) their kinetic energy and their momentum?
Assume that the mass of a muon is 207 times that of an electron.

5.(a) Assume that lattice points in a sc and fcc structure are occupied by spherical atoms of radius R. If the lattice constant is a for both lattice structures calculate the free volume per unit cell and determine the radius of the largest atom that will fit into the space at the body center.

(b) Sketch the planes having Miller indices (110), (001), $(\bar{1}\,\bar{1}\,0)$ and (111) of a fcc lattice.

(c) Derive Bragg's law of x-ray diffraction in crystals.
Give a short account of an experimental technique to determine the crystal structure of a material in powder form.

6.(a) Show that the probability of occupying an energy level E by a hole is $P(E) = \dfrac{1}{e^{-\Delta E/KT}+1}$ where, $\Delta E = E - E_F$ and E_F is the Fermi energy.

(b) Show that for free electrons the density of states per unit volume is $D(E) = \dfrac{8\sqrt{2}\pi m^{3/2}}{h^3}\sqrt{E}$

(c) Using the results in (b) show that the Fermi energy of a free electron like metal at 0^0K is $E_F = \dfrac{0.121h^2}{m}n^{2/3}$.

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