RAJARATA UNIVERSITY OF SRI LANKA
FACULTY OF APPLIED SCIENCES

B.Sc. (General) Degree in Applied Sciences
Second Year - Semester II Examination – November/December 2016

PHY 2105 – QUANTUM MECHANICS

Time: One (01) hour

Answer any two questions.

Use of a non-programmable calculator is permitted.

Symbols have their usual meaning.

Some fundamental constants and physical data:

Electron mass $m_e = 9.1 \times 10^{-31}$ kg
Speed of light in vacuum $c = 3.0 \times 10^{8}$ m s^{-1}
Bohr radius $a_0 = 0.529 \times 10^{-10}$ m
Planck constant $h = 6.626 \times 10^{-34}$ J s
Electron volt (1 eV) $= 1.6 \times 10^{-19}$ J
Proton mass $m_p = 1.672 \times 10^{-27}$ kg

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1. (a) Consider a particle of mass m, moving in a one-dimensional infinite square well of width L, such that the left corner of the well is at the origin. Obtain the energy eigenvalues and the corresponding normalized wave functions of the particle. **(20 marks)**

(b) An electron is confined to a one-dimensional motion between two rigid walls separated by a distance L.

i. What is the probability of finding the electron within the interval from $x = 0$ to $x = L/3$ from one wall if the electron is in its ground state? **(12 marks)**

ii. Compare this value with the classical probability. **(08 marks)**

(c) Show that the de Broglie wavelength of a particle in a one-dimensional box in the first excited state is equal to the length of the box **(10 marks)**

Contd.

2. (a) i. What is Compton effect? **(08 marks)**

ii. What are the assumptions made to explain the above effect? **(07 marks)**

(b) i. An electron initially at rest recoils from a head-on collision with a photon. Show that the maximum kinetic energy acquired by the electron is given by $\frac{2h\nu\alpha}{(1+2\alpha)}$, where α is the ratio of the photon's initial energy to the rest energy of the electron. i.e. $\alpha = h\nu / m_0c^2$.

Hint: Kinetic energy of the recoil electron is $h\nu - h\nu'$ and the Compton shift is $\Delta\lambda = \lambda' - \lambda = \frac{h}{m_0c}(1-\cos\theta)$. **(20 marks)**

ii. Calculate the maximum kinetic energy that can be transferred to an electron in a Compton scattering experiment when the wavelength of incident beam of X-rays is 1.0×10^{-10} m. **(10 marks)**

iii. Is it possible for a photon to transfer all of its energy to the electron in a Compton scattering? Explain. **(05 marks)**

3 (a) i. State Heisenberg's uncertainty principle and prove that $\Delta E.\Delta T \geq \hbar$. **(15 marks)**

ii. Use the above relation to explain how one could describe the broadening of spectral lines. **(08 marks)**

(b) An atom in an excited state with an energy of 1.8 eV above the ground state remains in that excited state on the average of 2 μs before undergoing a transition to the ground state.

i. Find the frequency and the wavelength of the emitted photon. **(10 marks)**

ii. Calculate the approximate uncertainty in the energy of the photon. **(10 marks)**

(c) "Electron Microscope is more suited to see objects of atomic size than an optical microscope". Justify this statement. **(07 marks)**

End.