RAJARATA UNIVERSITY OF SRI LANKA
FACULTY OF APPLIED SCIENCES

B.Sc. (General) Degree
Second Year – Semester II Examination – September/October 2013

PHY 2105- Quantum Mechanics

Answer any **two** questions Time: One hour

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	Planck constant $h = 6.626 \times 10^{-34}$ J s
Speed of light in vacuum $c = 3.0 \times 10^{8}$ m s^{-1}	Electron charge $e = 1.6 \times 10^{-19}$ C
Electron volt $eV = 1.6 \times 10^{-19}$ J	Acceleration due to gravity $g = 9.8$ m s^{-2}
Rydberg constant $R_H = 1.097 \times 10^{7}$ m^{-1}	Proton mass $m_p = 1.672 \times 10^{-27}$ kg

1. (a) Show that the allowed energies of a particle confined to move inside a one-dimensional infinite well of width L is given by $E = \dfrac{n^2\pi^2\hbar^2}{2mL^2}$, n is an integer an m is the mass of the particle. [10 pts.]

(b) Derive an expression for the wavelength of the photon emitted when a particle of mass m in an infinite well of width $2a$ makes a transition from a higher state of quantum number n_2 to a lower state of quantum number n_1. [20 pts.]

(c) A beam of photons in a range of wavelengths $\lambda = (9.0 \pm 1.0)$ nm strikes an electron in an infinite well of width 1.0 nm. The electron is in the ground state. To what higher states can the electron be excited? [20 pts.]

Contd.

2. (a) Describe the double-slit experiment using an electron beam. Show that the results of this experiment can be explained only if the uncertainty principle is assumed to be valid. [25 pts.]

(b) A nucleon (neutron or proton) is confined to a nucleus of radius 5×10^{-15} m. Calculate the minimum possible values of the momentum and the kinetic energy of the nucleon. [25 pts.]

3. (a) What is Compton effect? [10 pts.]

(b) A photon of frequency ν is scattered from a free electron at rest through an angle θ. Show that the kinetic energy of the recoil electron is equal to $h\nu \dfrac{\alpha(1-\cos\theta)}{1+\alpha(1-\cos\theta)}$, where $\alpha = h\nu / m_0 c^2$ and m_0 is the rest mass of the electron.

Hint: Kinetic energy of the recoil electron is $h\nu - h\nu'$ and the Compton shift is $\Delta\lambda = \lambda' - \lambda = \dfrac{h}{m_0 c}(1-\cos\theta)$. [20 pts.]

(c) i. What is the maximum kinetic energy that can be imparted to a free electron by a photon of initial frequency ν? [10 pts.]

ii. Is it possible for the photon to transfer all of its energy to the electron? Explain. [10 pts.]

End.