EASTERN UNIVERSITY, SRI LANKA

SECOND EXAMINATION IN SCIENCE – 2010/2011

FIRST SEMESTER (PROPER/REPEAT)

APRIL/MAY 2013

PH 201 ATOMIC PHYSICS AND QUANTUM MECHANICS

Time: 02 hours

Answer ALL Questions

You may use the following information useful.

Charge of an electron $e = 1.602 \times 10^{-31} C$

Mass of an electron $m_e = 9.109 \times 10^{-31}\ kg$

$1\ eV = 1.602 \times 10^{-19} J$

1. (a) State the postulates of Bohr theory and derive an expression for the energy of the n^{th} orbit of hydrogen like atom.

(b) Describe the main features of the X-ray spectrum of an element and explain the origin of the characteristic line in the spectrum.

Based on the results obtained from the Bohr theory, deduce an equation for Moseley's law.

X-rays emitting from a discharge tube equipped with a Cobalt target produces K_α lines of wavelength 1.785Å for Cobalt, and wavelength 2.285Å due to an unknown elemental impurity in the target. Calculate the atomic number of the impurity element; given that the atomic number of Cobalt is 27 and the screening constant for K_α line is 1.

2. Explain briefly the nature of the Zeeman effect in an applied magnetic field.

The sample of atomic hydrogen is placed in a weak magnetic field of strength B. If the hydrogen atom makes the transition from state $n = 2$ to $n = 1$ and establishes emission of three spectral lines, show that the wavelength of these three lines are approximately given by

$$\lambda_1 = \lambda_0 + \Delta\lambda$$

$$\lambda_2 = \lambda_0$$

$$\lambda_3 = \lambda_0 - \Delta\lambda$$

where λ_0 is the wavelength of the radiation emitted by the transition in absence of the magnetic field, and $\Delta\lambda = \frac{eB\lambda_0^2}{4\pi m_e}$ is the wavelength separation of Zeeman splitting. The other symbols have their usual meanings.

In the above case, calculate the wavelength separation of Zeeman splitting when the magnetic field is 0.4 T and wavelength of the transition is 6000Å.

3. (a) Explain briefly how can you differentiate the physics phenomena of photoelectric effect from that of Compton effect.

(b) Write down Einstein's equation adopted in photoelectric effect and show how it explain the main features of the effect.

(c) Outline an experiment to determine the Planck's constant h and the work function W of a metal surface.

When a rubidium surface is illuminated by light of wavelengths 3629Å and 5420Å photoelectrons are emitted with maximum kinetic energies of 1.32 eV and 0.19 eV respectively. Calculate the Planck's constant and the work function of the rubidium.

4. (a) Write down the time independent Schrödinger wave equation in a rectangular Cartesian co-ordinate system for a particle of mass m and the energy E moving in a potential V.

(b) Write down the time independent Schrödinger equation for the motion of particles having energy $E(> V_0)$ and mass m in an one dimensional potential barrier shown in the figure. Using the boundary conditions, show that the transmission coefficient T is given by

$$T = \frac{4\sqrt{E(E-V_0)}}{\left[\sqrt{E}+\sqrt{(E-V_0)}\right]^2}$$