EASTERN UNIVERSITY, SRI LANKA

SECOND EXAMINATION IN SCIENCE 2002/03 (OCT-DEC. 2006)

FIRST SEMESTER

EXTERNAL DEGREE

EXTPH 201 - ATOMIC PHYSICS AND QUANTUM MECHANICS

Time: 02 hours.

Answer ALL Questions.

You may use the following information.

Electron charge $e = 1.6 \times 10^{-19} C$

Permittivity in free space $\varepsilon_0 = 8.85 \times 10^{-12} Fm^{-1}$

Velocity of light $c = 3 \times 10^{8} ms^{-1}$

Planck's constant $h = 6.625 \times 10^{-34} Js$

01. Derive Rutherford's Scattering formula and mention the important features of Rutherford's Scattering of α-particles by gold foil which supported the nuclear model of the atom against Thomson's model.

Calculate the distance of closest approach when α particles of energy $5MeV$ are scattered back by a thin sheet of copper $(Z = 29)$.

02. Briefly explain the nature of the Zeeman effect in a magnetic field.

A sample of atomic hydrogen is placed in a magnetic field strength B. If the hydrogen atom makes a transition from $n = 2$ to $n = 1$ state, three spectral lines are emitted. If the wavelength of the radiation emitted by this transition in the absence of the magnetic field is λ_0, when in the presence of a weak magnetic field, show that the change in frequency of the spectral lines is given by $\Delta\gamma = \pm \frac{eB}{4m\pi}$.

03. (a) Explain what is photoelectric effect and establish Einstein's photoelectric effec equation.

A certain photo tube requires 1 volt to serve as the stopping potential for light o wavelength $500A^0$. If the light has the wavelength of $3750A^0$ the stoppin potential is 1.82 volts. Calculate $\frac{h}{e}$ from this data.

(b) State and explain the Heisenberg's uncertainty principle.

Find the smallest possible uncertainty in the position of an electron moving wit velocity $3\times10^7 ms^{-1}$.

04. (a) The wave function of the electron in a hydrogen atom is given by

$$\psi(r) = Ae^{-\left(\frac{r}{a}\right)}$$, where A and a are constant.

Estimate,

(i) the normalization constant

(ii) expectation value of r

You may assume that $\int_0^\infty r^n e^{-\left(\frac{r}{a}\right)} dr = n!a^{n+1}$.

(b) (i) Write down the time-independent Schrödinger equation in a rectangula Cartesian Co-ordinate system, for a particle of mass m and the energy E moving in a potential V.

(ii) Calculate the possible values of energies for an electron in an atom which ma be considered as a particle moving inside an infinite square potential well o width a, described by

$$V = 0,\ 0 \le x \le a$$

$$V = \infty,\ |x| \ge a.$$