EASTERN UNIVERSITY, SRI LANKA

SECOND EXAMINATION IN SCIENCE - 2004/2005

FIRST SEMESTER - JANUARY/FEBRUARY 2006

PH 201 - ATOMIC PHYSICS AND QUANTUM MECHANICS

Answer ALL questions.

Time: 2 hours

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1. What is the Compton effect?

Use the explanation of quantum theory to show that the change in the wavelength of X-ray photon on scattering from a free electron is independent of the wavelength of the incident radiation.

Explain why Compton effect is experimentally not observed for visible light rays.

(a) Show that the maximum recoil energy of a free electron of rest mass m_0, when struck by a photon of frequency ν, is given by

$$K_{max} = \frac{(h\nu)^2}{h\nu + \frac{1}{2}m_0c^2}.$$

(b) If λ is the wavelength of the photon and λ_e the Compton wavelength of the electron, then show that

$$K_{max} = \frac{2m_0c^2\lambda_e^2}{\lambda^2 + 2\lambda_e\lambda}.$$

2. (a) State the postulates of Bohr regarding his atomic model and hence obtain an expression for the electron energy of the n^{th} orbit. Why could not Bohr allow the principle quantum number n to take on the value $n = 0$?

(i) Calculate the value of the Rydberg constant, assuming that wavelength of H_α line is $6563\mathring{A}$.

(ii) What are the wavelengths of the first two lines of the Pachen series?

(b) State and explain Pauli's exclusion principle as applied to electrons in atoms. On the basis of this principle write down the electron configuration for $Cu(29)$ employing modern symbolism and explain it.

3. (a) Discuss Heisenberg's uncertainty principle and explain its validity by microscope thought experiment.

The average period that elapses between the excitation of an atom and the time it emits radiation is 10^{-8} *sec.* Find the uncertainty in the energy emitted and uncertainty in the frequency of the light emitted.

(b) Explain briefly what do you understand by photoelectric effect and give Einstein's explanation for the same.

A certain metal has a threshold wavelength of 600 nm. Find the stopping potentials when the metal is irradiated with

(i) Monochromatic light of wavelength 400 nm.

(b) Light having twice the frequency and three times the intensity of wavelength 400 nm.

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

A beam of particles each of mass m and energy E, moving in a region of zero potential energy, approaches a rectangular potential barrier of width a and height V_0, where $V_0 > E$.

If $\beta a \gg 1$, where $\beta = \sqrt{\dfrac{2m(V_0 - E)}{\hbar^2}}$, prove that the transmission coefficient is given by

$$T = \frac{16E}{V_0}\left[1 - \frac{E}{V_0}\right] e^{-2\beta a}.$$