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EASTERN UNIVERSITY, SRI LANKA

SECOND EXAMINATION IN SCIENCE - 2000/2001

(May 2001)

PH201 - Atomic Physics and Quantum Mechanics

Time: 02 hours.

Answer All questions.

2001/May

1. State the postulates of Bohr theory. Derive an expression for the total energy of the n^{th} Bohr's orbit of the Bohr atom and explain its significants. Hence, show that the wavelength of the electromagnetic radiation emitted in a transition between two states of a Bohr atom as

$$\frac{1}{\lambda} = R\left(\frac{1}{n_f} - \frac{1}{n_i}\right),$$

where λ is the wavelength of the radiation, R is the Redberg constant and n_i and n_f are integers.
Deduce the wavelength λ_α of the H_α-line in the Balmer series of H-atom as

$$\frac{1}{\lambda_\alpha} = \frac{5R_H}{36},$$

where R_H is the Redberg constant for H-atom.
If the wavelength of the H_α-line in the Balmer series of H-atom is $6563\mathring{A}$, find

(a) a value for the Redberg constant and

(b) the shortest wavelength in the Balmer series limit.

2. Explain briefly the nature of the Zeeman effect in a magnetic field.
A hydrogen atom makes the transition from $n = 2$ to $n = 1$ state, in which light of frequency ν_0 is emitted. Show that in a magnetic field B, the emitted radiation can now have frequencies

$$\nu_0 + \frac{eB}{4\pi m}, \qquad \nu_0 \qquad \text{and} \qquad \nu_0 - \frac{eB}{4\pi m}$$

In the above case calculate the wavelength separation between the two component lines which are observed in Zeeman effect in the magnetic field of 0.4 *Tesla*. The wavelength of the radiation is $6000\mathring{A}$ and $\frac{e}{m}$ is 1.76×10^{11} *Coulomb* kg^{-1}.

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3. Explain what is meant by Compton effect?
Show that the change in wavelength of a photon subject to Compton scattering by an electron is given by

$$\Delta\lambda = \frac{h}{m_0 c}(1 - \cos\phi)$$

where ϕ is the scattering angle and the other symbols have their usual meanings.
In a Compton effect, show that the kinetic energy imparted to the recoiling electron as

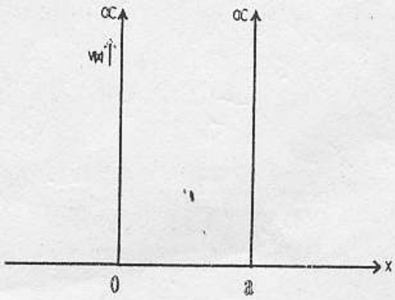
$$\frac{hc\Delta\lambda}{\lambda^2}$$

If X-ray of wavelength $\lambda = 1.0\mathring{A}$ is scattered from a carbon block find

(a) the maximum Compton shift

(b) the kinetic energy imparted to the recoiling electron when the photon recoils at 90^0 to the incident beam.

4. Write down the time independent Schrdinger equation in a rectangular cartesian coordinate system, for a particle of mass m and the energy E moving in a potential V.
A particle of mass m and the energy E moves inside a potential well $V(x)$ as shown in the figure



$$V(x) = 0 \quad \text{for} \quad 0 \leq x \leq a,$$
$$V(x) = \infty \quad \text{for} \quad x < 0, \text{ and } x > a.$$

(a) Write down the time independent Schrdinger equation for the motion of the particle.

(b) State clearly the boundary conditions and the normalization condition for the wavefunction.

(c) Using the above conditions, show that the wavefunction of the particle as

$$\psi = \sqrt{\frac{2}{a}} \sin\left(\frac{n\pi}{a}\right) x.$$