EASTERN UNIVERSITY, SRI LANKA

SECOND EXAMINATION IN SCIENCE - 1996/97

(JUNE-AUGUST 2004)

EXTERNAL DEGREE

EXPH 201 ATOMS AND GASES AND QUANTUM MECHANICS

Time: 02 hours.

Answer FOUR Questions selecting TWOfrom each section

You may assume the following information

(i) charge of electron $e = 1.602 \times 10^{-19}C$

(ii) mass of electron $m_e = 9.109 \times 10^{-31}kg$

(iii) Planck's constant $h = 6.26 \times 10^{-34}Js$

(iv) velocity of light$= 3 \times 10^{8}ms^{-1}$

(v) $1eV = 1.602 \times 10^{-19}C$

SECTION A

1. Explain what is photoelectric effect and give Einstein's interpretation for the same. Write down Einstein's photoelectric equation and explain the meaning of the following terms.

   (i) Work function

   (ii) Threshold frequency.

   (iii) Stopping potential.

   A metallic surface when illuminated with light of wavelength $3333A^0$ emits electrons with energies up to $0.6eV$ and when illuminated with light of wavelength $2400A$, it emits electrons up to $2.04eV$. Calculate Planck's constant and the work function of the metal (in electron volt).

2. State the postulates of Bohr regarding his atom model. Obtain expressions for the radius and electron-energy of the n^{th} orbit.

   (ii) Show that the velocity of the electron in the first Bohr orbit is $(\frac{1}{137})c$ where c is the velocity of light.

   (ii) Calculate the radius and energy of the electron in the 2^{nd} excited state for Hydrogen atom.

3. Using the simple kinetic theory, obtain expressions for

   (i) Mean free path of a gas molecule

   (ii) The viscosity of a gas.

   Use your results to investigate the dependence of viscosity on pressure and temperature of the gas.
   When air at $1atm$ pressure and 300K has a viscosity of $1.85\times10^{-6}Kgm^{-1}s^{-1}$. Estimate its viscosity at $2atm$ and $363K$.

SECTION B

4. What do you understand by Comton effect? Briefly discuss the differences between Compton effect and Photcelectric 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.

Show that the ratio of the kinetic energy of the recoil electron to the energy of the incident photon is given by

$$\frac{\Delta\lambda}{\lambda + \Delta\lambda}$$

where λ is the wavelength of incident photon.

5. Write down the time independent Schrodinger's equation. Use this equation for a particle of mass m and energy E confined into a infinite square well of length a. Show that the energy E is given by the equation

$$E = \frac{\pi^2\hbar^2}{2ma^2}n^2$$

where n is a real number. Using normalization condition show that the wave equation $U(x)$ for that particle is

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

6. The wave function $\psi(x,t)$ of a prtticle can be expressed as

$$\psi(x,t) = Ae^{-\left(\frac{\sqrt{Cm}}{2\hbar}\right)x^2} e^{-\left(\frac{i}{2}\right)\sqrt{\frac{C}{m}}t}$$

where A, C are constants and the other symbols have their usual meanings.

(i) Verify that this expression is a solution of the time dependent Schrodinger equation for the potential given by $V(x) = \frac{Cx^2}{2}$

(ii) using normalization condition show that

$$A = \frac{(Cm)^{\frac{1}{8}}}{(\pi\hbar)^{\frac{1}{4}}}$$