Uva Wellassa University, Sri Lanka
End Semester Examination - June/July -2009
CHE 283-1/PHY 261 -1 Quantum Mechanics (Repeat)

Time: One (01) Hour

Total **06** questions
Answer **four (04)** questions only
Calculators are allowed

Planck's constant (h) = 6.63×10^{-34} Js
Electron charge (e) = 1.602×10^{-19} C
Velocity of Light in vacuum (C) = 3×10^{8} ms^{-1}

1). I. Radiation in the ultraviolet region of the electromagnetic spectrum is usually described in terms of wavelength, λ, and is given in angstrom units (1 Å = 10^{-10} m). Calculate frequency, ν, wave number, $\bar{\nu}$, and energy, E, for ultraviolet radiation with wavelength, λ, 2000 Å.

(8 marks)

II. Radiation in the infrared region is often expressed in terms of wave numbers which is expressed as the inverse of wavelength. A typical value of wave number in this region is 10^3 cm^{-1}. Calculate, ν, λ, and E for radiation with wave number 10^3 cm^{-1}.

(8 marks)

III. Past the infrared region, in the direction of lower energies, is the microwave region. In this region, radiation is usually characterized by its frequency ν, expressed in units of megahertz (MHz), A typical microwave frequency is 2.0×10^4 MHz. Calculate wave number, $\bar{\nu}$, wavelength, λ, and energy, E.

(9 marks)

2). I. Explain Einstein's photoelectric effect. The work function of a material refers to the minimum energy required to remove an electron from the material. Assume that the work function of gold is 4.90 eV and that of cesium is 1.90 eV. Calculate the maximum wavelength of light for the photoelectric emission of electrons for gold and cesium.

(15 marks)

II. An electron and a photon have the same energy. At what value of energy (in eV) will the wavelength of the photon be 10 times that of the electron

(10 marks)

3). I. State the de Broglie hypothesis. Explain briefly why it is not possible to observe wave-like properties of macroscopic objects even when they are in motion.

(10 marks)

II. It is desired to produce X-ray radiation with a wavelength of 1 Å.

(a). Through what potential difference must the electron be accelerated in a vacuum so that it can, upon colliding with a target, generate such a photon? (assume that all of the electron's energy is transferred to the photon).

(10 marks)

(b). What is the de Broglie wavelength of the electron in part (I) just before it hits the target?

(5 marks)

4). I. State the Heisenberg's uncertainty principle.

(5 marks)

II. Imagine you are attempting to locate (i.e., "to see") an electron in the first Bohr orbit within a distance of Δx where Δx is in the pm range. Argue to show that the Δp uncertainty caused in the momentum of the electron is due to the very fundamental nature of the act of the measurement (i.e., attempting to locate) itself.

(10 marks)

III. Calculate the uncertainty in the position of a baseball thrown at a 90 mph if we measure its velocity to a millionth of 1 %. Mass of the baseball is 150g.

(10 marks)

5). I. Give the Born interpretation for the wave function of the time-dependent Schrödinger equation.

(5 marks)

II. Show that if $\Psi_1(x)$ and $\Psi_2(x)$ are solutions to the one-dimensional time-independent Schrödinger equation, then $\Psi_1 + \Psi_2$ is also a solution to the equation.

(10 marks)

III. A wave function has the form of $\Psi(x) = Axe^{-2x}$ for $0 \leq x \leq 1$. Find A so that

$$\int_0^1 |\Psi(x)|^2 \, dx = 1$$

Hence find the normalized wave function

(10 marks)

6). By solving the 1-D time-independent Schrodinger equation for each case, show that although the energy of a particle confined into one-dimensional infinite potential well ("a particle in a box") is quantized, the energy of a particle moving in a free space with zero potential function is not quantized.

Show clearly the boundary conditions you used to solve the 1-D Schrödinger equation in each case.

(25 marks)