Uva Wellassa University, Sri Lanka
End Semester Examination - June/July -2010
CHE 283-1/PHY 261 -1 Quantum Mechanics
(Repeat Examination)

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 a wavelength, λ, 2340 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 2 x10^3 cm^{-1}.

(8 marks)

III. Past the infrared region, in the direction of lower energies, is the microwave region. Radiation is usually characterized by its frequency ν, expressed in units of megahertz (MHz), A typical microwave frequency is 4.0 x 10^4 MHz. Calculate wave number, $\bar{\nu}$, wavelength, λ, and energy, E.

(9 marks)

2). Explain photoelectric effect. What do you mean by the work function of a given material? Explain briefly how the conditions of a surface can affect the work function of a material. Work function of Chromium (Cr) is 4.40 eV. Calculate the kinetic energy of electron emitted from a Chromium (Cr) surface when it is irradiated with UV radiation of wavelength 2000 Å. What is the stopping potential for these electrons?

(25 marks)

3). I. Give an experimental evidence to show that the light has a wave nature. State 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 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). 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 used to solve the 1-D Schrödinger equation in each case.

(25 marks)

6). 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 $\Psi(x) = Ae^{-2x^2}$ for $0 \leq x \leq 1$. Find A so that

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

State the normalized wave function.

(10 marks)