BOWEN UNIVERSITY, IWO, OSUN STATE NIGERIA

COLLEGE OF AGRICULTURE, ENEGINEERING, AND SCIENCE

PHYSICS PROGRAMME

2022/2023 SECOND SEMESTER EXAMINATION

PHY 342 **QUANTUM PHYSICS** **(3 CREDITS)**

DATE: 22nd June, 2023 **TIME: 8:30 – 11:30am**

ANSWER FOUR QUESTIONS

Plank's constant	h	6.6×10^{-34} J.s
Stefan-Boltzman constant	σ	5.67×10^{-8} Watts.$m^{-2}K^{-4}$
Wien's displacement constant	b	2.898×10^{-3} m.k
Speed of light	c	$3.00 \times 10^{8} ms^{-1}$
Electron rest mass	m_e	9.11×10^{-31}Kg
Neutron rest mass	m_n	1.649×10^{-27}Kg
Rydberg constant	R	$1093700m^{-1}$
1eV		1.6×10^{-19}J
Gravitational Constant	G	$6.67 \times 10^{-11} m^3kg^{-1}s^{-2}$
Latent heat of vaporization	L_v	2256 $kJkg^{-1}$
Latent heat of fusion of water	L_{fw}	338 $kJkg^{-1}$
STP		1.01×10^5Pa
Velocity of sound in air		$330ms^{-1}$
Density of water	ρ	$1 \times 10^3 kg/m^3$

Q1

a. With the aid of an appropriate diagram show the radiant energy (J) vs wavelength (m) in a black body radiation. **(5 marks)**

b. Assume that black body ("Planckian") radiance per unit frequency interval is given by

$$\rho(\lambda) = \frac{8\pi hc}{\lambda^5} \frac{1}{e^{\frac{hc}{\lambda KT}} - 1}$$

where
c = velocity, h = plank's constant, T = Temperature and K = Boltmann's constant
Show that

$$E = aT^4$$

Where other symbols have their usual meaning. **(20 marks)**

Q2

a. Discuss the postulate of Bohr Atom on energy level over classical mechanics. **(5 marks)**

b. Using the postulate of Bohr Atom on energy level, show that:

$$V_{ab} = \frac{m}{4\hbar^2}\left(\frac{Ze^2}{4\pi\varepsilon_0}\right)^2\left(\frac{1}{n_a^2} - \frac{1}{n_b^2}\right)$$

From $hv = E_b - E_a$, where E_a and E_b are the internal energies of the atom in the initial and final state with $E_b > E_a$. Where n_a and n_b are positive integers and $n_b > n_a$. **(20 marks)**

Q3

a. What do you understand by the term Photoelectric effect? **(2 marks)**

b. From the assumption of Einstein, the incident radiation consists of little packets of energy, and quanta of light called photon, each of energy $E = hf$.
Where h is the Planck's constant and v is the frequency of the incident radiation, show that

$$V_0 = \frac{mV_{max}^2}{2e}$$

Other symbols have their usual meaning. **(5 marks)**

c. A photon with wavelength λ collides with an electron at rest. After the collision, the photon is scattered in direction θ relative to its initial direction. The electron is also scattered at an angle ϕ with respect to the reference direction. Show that

$$\Delta\lambda = \frac{h}{m_e c}(1 - \cos\theta)$$

Where all the symbols have their usual meaning. **(18 marks)**

Q4

a. Derive the time dependent Schrodinger 1-D equation and explain its physical significance **(13 marks)**

b. What would be the potential function if

$$\psi(x) = \left(\frac{x}{x_0}\right)^n e^{-2x/x_0}$$ **(12 marks)**

is an Eigen function of the Schrodinger equation (Assume that when $x \to \infty$, $V(x) \to 0$).

Q5

a. Show that the commutator

(i) $[x^2, P_x] = 2i\hbar x$ (ii) $\left[x, \frac{d}{dx}\right] f(x) = -1$ **(6 marks)**

(iii) Use the uncertainty principle to obtain the ground state energy of a linear oscillator. **(5 marks)**

(iv) Given that $\langle P_x \rangle = P_o$, $\langle P_x^2 \rangle = P_o^2 + \frac{\hbar^2}{4\alpha^2}$, $\langle x \rangle = 0$, $\langle x^2 \rangle = \alpha^2$. Show that:

$$\Delta x \Delta P_x \geq \frac{\hbar}{2}$$

where all symbols have their usual meaning. **(4 marks)**

b. What are the allowable eigenfunction of the infinite potential well.

$$V(x) = \begin{cases} 0, -L \leq x \leq L \\ \infty, else\ where \end{cases}$$

Where all parameters have their usual meaning. **(10 marks)**