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Universiti Tun Hussein Onn Malaysia

UNIVERSITI TUN HUSSEIN ONN MALAYSIA

FINAL EXAMINATION
SEMESTER II
SESSION 2018/2019

COURSE NAME	:	QUANTUM PHYSICS
COURSE CODE	:	BWC 20803
PROGRAMME CODE	:	BWC
EXAMINATION DATE	:	DECEMBER 2018/JANUARY 2019
DURATION	:	3 HOURS
INSTRUCTION	:	ANSWERS **ALL** QUESTIONS

THIS QUESTION PAPER CONSISTS OF **THREE (3)** PAGES

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Q1 (a) Define the time-independent Schrodinger equation.
(3 marks)

(b) Find $V(x)$ such that the Schrodinger equation is satisfied using

$$\psi(x,t) = A(x - x^3)e^{\frac{-iEt}{\hbar}}$$

(7 marks)

(c) Determine the probability that a particle is located in the region of $a \le x \le b$.
(3 marks)

(d) Find A such that $\psi(x) = Ae^{-\lambda(x-x_0)^2}$ is normalized. The constant λ and x_0 are real.
(7 marks)

Q2 A beam of particles coming from $x = -\infty$ meets a potential barrier described by $V(x) = V$, where V is a positive constant, at $x = 0$. There are two regions in this potential barrier which are region I at $x < 0$ and region II at $x > 0$. Consider the incident beam of particles to have energy $E > V$.

(a) Find the transmission and reflection coefficients for this potential.
(15 marks)

(b) What is Scanning Tunneling Microscope (STM)?
(5 marks)

Q3 (a) Given $|\psi\rangle = \begin{pmatrix} 2 \\ 3i \\ -2 \end{pmatrix}$, $|\phi\rangle = \begin{pmatrix} 0 \\ -2 \\ 1 \end{pmatrix}$.

(i) Find $|\psi\rangle^{+}$, $|\phi\rangle^{+}$, $\langle\psi|\phi\rangle$ and $\langle\phi|\psi\rangle$.
(6 marks)

(ii) What is your conclusion in **Q3(a)(i)** and its relation with Hermitian matrix?
(2 marks)

(b) Explain the Hermitian equation in terms of eigenvalue and eigenfunction.
(4 marks)

(c) In describing photon polarization at 45° angle, how do you get $|/\rangle = \begin{pmatrix} \frac{1}{\sqrt{2}} \\ \frac{1}{\sqrt{2}} \end{pmatrix}$ given that $|x\rangle = \begin{pmatrix} 1 \\ 0 \end{pmatrix}$ and $|y\rangle = \begin{pmatrix} 0 \\ 1 \end{pmatrix}$?
(8 marks)

Q4 (a) Transform the harmonic oscillator in classical physics into quantum physics.

(5 marks)

(b) Given that the position and the momentum operators are defined as $a = \sqrt{\frac{m\omega}{2\hbar}}\left(x + \frac{ip}{m\omega}\right)$ and $a^{+} = \sqrt{\frac{m\omega}{2\hbar}}\left(x - \frac{ip}{m\omega}\right)$. Show that the harmonic oscillator Hamiltonian can be written in the form of $H = \hbar\omega\left(a^{+}a + \frac{1}{2}\right)$.

(8 marks)

(c) From **Q4(b)**, derive the energy eigenstate.

(7 marks)

Q5 (a) State **THREE (3)** of the postulates in quantum physics. Write in brief statements.

(4 marks)

(b) Consider the orbital angular momentum. A system with $l = 1$ is in the state

$$|\psi\rangle = \frac{1}{\sqrt{2}}|1\rangle - \frac{1}{2}|0\rangle + \frac{1}{2}|-1\rangle.$$

Calculate $\langle L_y \rangle$.

(8marks)

(c) A spin $\frac{1}{2}$ is in the state $|\psi\rangle = \frac{1+i}{\sqrt{3}}|+\rangle + \frac{1}{\sqrt{3}}|-\rangle$.

(i) If spin is measured in the $z-$direction, what are the probabilities of finding $\pm\frac{\hbar}{2}$?

(3 marks)

(ii) If spin is measured in the $x-$direction, what are the probabilities of finding spin-up?

(3 marks)

(iii) Calculate $\langle S_z \rangle$.

(2 marks)

-END OF QUESTIONS -