Quiz 3 - Quantum Mechanics I

NAME: _____ SCORE:

Date: Thursday 1 December 2022   **Duration:** 60 minutes
Credits: 20 points (10 questions)   **Type of evaluation:** LAB

Part A. <u>Choose</u> the correct answer to each question or statement given below, and briefly <u>justify</u> your choice in the white space assigned to each of them. <u>Unjustified answers</u> will not count to the final grade.

1. **(2 points) Planck equation**
   If the wavelength of electromagnetic radiation is halved, the energy of photons:

   A. remains the same.
   B. doubles.
   C. is halved.
   D. is infinite.

2. **(2 points) de Broglie wavelength**
   A proton has four times the momentum of an electron. If the electron has a de Broglie wavelength λ_e, what is the de Broglie wavelength of the proton?

   A. λ_e
   B. $\frac{\lambda_e}{16}$
   C. $4\lambda_e$
   D. $\frac{\lambda_e}{4}$

3. **(2 points) Quantum harmonic oscillator**
   The ground energy value, E_0, of a quantum harmonic oscillator is:

   A. $\frac{3}{2}\hbar\omega$
   B. $\hbar\omega$
   C. $\frac{1}{2}\hbar\omega$
   D. 0

4. **(2 points) Finite square well potential**
   What type of stationary state solutions does a finite square well potential allow?

   A. Only bound states.
   B. Only scattering states.
   C. Both bound and scattering states.
   D. No solutions.

5. **(2 points) Delta-function well**
   How many bound states does a delta potential well allow?

   A. Only 1 state.
   B. n states where n is odd.
   C. n states where n is even.
   D. n states for n even or odd.

6. **(2 points) Infinite square well potential**
   A particle is in an infinite square well potential with walls at $x = 0$ and $x = L$. If the particle is in the state $\psi(x) = A\sin\left(\frac{3\pi x}{L}\right)$, where A is a constant, what is the probability that the particle is between $x = \frac{1}{3}L$ and $x = \frac{2}{3}L$?

   A. $\frac{1}{3}$
   B. 1
   C. $\frac{1}{\sqrt{3}}$
   D. $\frac{2}{3}$

Part B. Provide <u>concise answers</u> to the following items:

8. **(3 points) The time-independent Schrödinger equation**
   Write down the time-independent Schrödinger equation, and indicate: what steps do we follow to solve it in a general case?

9. **(3 points) Bound states and scattering states**
   (a) Write down two differences between bound states and scattering states.

   (b) Provide one example of potentials that allow (i) only bound states, (ii) only scattering states, and (iii) both bound and scattering states.

10. **(2 points) Wave packets: free particles**
    Mathematically speaking, what are wave packets composed of? Briefly explain.