Quiz 1 - Quantum Mechanics I

NAME: _____ **SCORE:**
Date: Thursday 1 December 2022 **Duration:** 45 minutes
Credits: 20 points (10 questions) **Type of evaluation:** LAB

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

1. **(2 points) Units of the Planck constant, h**
   If [M], [L], and [T] represent the dimensions of mass, length, and time, respectively, what are the dimensions of the Planck constant, h?

   A. $[\mathrm{M\,L^2\,T}]$
   B. $[\mathrm{M\,L^2\,T^{-3}}]$
   C. $[\mathrm{M\,L^2\,T^{-2}}]$
   D. $[\mathrm{M\,L^2\,T^{-1}}]$

2. **(2 points) Black body radiation**
   The magnitude of the wavelength for which the maximum energy is emitted by a black body:

   A. decreases with an increase in temperature.
   B. increases with an increase in temperature.
   C. does not change with temperature.
   D. becomes infinite.

3. **(2 points) Photoelectric effect**
   Two metals A and B have work functions of 4 eV and 10 eV, respectively. Which metal has a higher threshold wavelength to produce a photoelectric effect?

   A. Both metals have the same threshold wavelength.
   B. Metal A
   C. Metal B

4. **(1 point) Compton scattering**
   For which scattering angle (θ in °) is the photon wavelength shift half the Compton wavelength of the scattered electron?

   A. $\theta = 30°$
   B. $\theta = 60°$
   C. $\theta = 90°$
   D. $\theta = 180°$

5. **(2 points) Wavelike and pointlike nature of particles**
   The length scale at which the concept of a single point-like particle breaks down is:

   A. the Bohr radius.
   B. the Planck's length.
   C. the Compton wavelength.
   D. the de Broglie wavelength.

6. **(2 points) Quantum superposition**
The state of a quantum system can be described as the superposition of two states, $|\Psi_1\rangle$ and $|\Psi_2\rangle$, as follows: $|\Psi\rangle = a\,|\Psi_1\rangle + b\,|\Psi_2\rangle$, where $|b| > |a|$. Upon measurement of the same property, $|\Psi_1\rangle$ returns A, and $|\Psi_2\rangle$ returns B, which value does $|\Psi\rangle$ return after measurement?

A. A
B. B
C. A or B
D. $a\,A + b\,B$

7. **(2 points) Expectation values**
In quantum mechanics, the expectation value of the position of a particle represents:

A. the average value of the position measured in repeated experiments on the same particle.
B. the average value of the position measured on identical particles in the same state.
C. the only possible value of its position.
D. the most probable value of its position.

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

8. **(2 points) The Schrödinger equation**
Write down the Schrödinger equation, and indicate what each term in it represents.

9. **(2 points) de Broglie's proposal**
Briefly explain what de Broglie's proposal consists of.

10. **(2 points) Wave functions**
Briefly describe 3 properties of wave functions in Quantum Mechanics.