GOVERNMENT ZIRTIRI RESIDENTIAL SCIENCE COLLEGE

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A. Multiple choice questions [25 (5 from each unit)]

1. The value of the de Broglie wavelength of an electron having kinetic energy of 9 eV is nearly

(a) 4 $\overset{0}{A}$

(b) 1.36 $\overset{0}{A}$

(c) 0.4 $\overset{0}{A}$

(d) 13.6 $\overset{0}{A}$

2. According to Schrodinger, a particle in motion is equivalent to

(a) a single wave

(b) a wave packet

(c) a group wave

(d) either (b) or (c)

3. For a relativistic particle moving with velocity v, its phase velocity is

(a) v

(b) v/2

(c) c^2/v

(d) v^2/c

4. Which of the following conditions can not be satisfied by a well-behaved wavefunction ψ ?

(a) ψ must be finite for all values of x, y and z

(b) ψ must be single-valued at each point

(c) ψ must be continuous for all regions

(d) ψ must be a real function of x, y, z, t.

5. If the wavefunction $\psi(r,t)$ is normalized, then $\int |\psi(r,t)|^2 \, dv$ has the value

(a) 0

(b) 1

(c) ½

(d) ∞

6. The quantity $\psi\psi^* = |\psi|^2$ indicates
(a) the probability density of finding a particle
(b) the total energy of the particle
(c) total probability of finding the particle
(d) None of the above.

7. The quantity $\int_{-\infty}^{\infty} \psi\psi^* dv$ indicates
(a) the probability density of finding a particle
(b) the total energy of the particle
(c) total probability of finding the particle
(d) expectation value of the particle

8. Which of the following is only acceptable quantum mechanical wave function ?
(a) $\psi = x$
(b) $\psi = x^2$
(c) $\psi = e^{-x^2}$
(d) $\psi = e^x$

9. The minimum energy in eV of the photon required to observe an object of size 4^0A is nearly
(a) 3 KeV
(b) 3 eV
(c) 1 KeV
(d) 2 eV

10. The quantum mechanical tunnelling provides explanation for the following physical phenomena except
(a) the emission of alpha-particles from a radioactive nucleus
(b) the motion of electrons inside an atom
(c) the electrical breakdown of insulators
(d) the switching action of a tunnel diode

11. If the operator $\hat{A} \equiv \frac{d^2}{dx^2}$ operates on the eigenfunction $\psi(x) = \sin 2x$, the eigenvalue is
(a) 1
(b) 2
(c) 4
(d) -4

12. Eigenvalues of Hermitian operators
(a) are real only
(b) are imaginary only
(c) can be real or imaginary
(d) are always complex

13. Total number of energy levels (or degeneracy) for the nth state of hydrogen atom is
(a) n
(b) n+1
(c) n^2
(d) n^2+1

14. The energy eigenvalue of a particle inside a one-dim box of side *a* is given by
(a) $E_n = \frac{nh}{8ma^2}$
(b) $E_n = \frac{n^2h}{8ma^2}$
(c) $E_n = \frac{n^2h^2}{8ma^2}$
(d) $E_n = \frac{n^2h^2}{8m^2a^2}$

15. If E be the ground state energy of a particle confined in a one-dim. box, then the allowed values of enegy for the excited states are
(a) 2E, 3E, 4E, …..
(b) 4E, 9E, 16E, …
(c) 4E, 6E, 8E, …..
(d) E/4, E/9, E/16, …

16. The momentum eigenvalue for a particle trapped in cubical box of side *a* in the ground state (1,1,1) is
(a) $\frac{3\pi\hbar}{a}$
(b) $\frac{\sqrt{3}\,\pi\hbar}{a}$
(c) $\frac{6\pi\hbar}{a}$
(d) $\frac{\sqrt{6}\,\pi\hbar}{a}$

17. “Zero point energy” of the linear harmonic oscillator means that, at the ground state, the total energy of the oscillator is
(a) 0
(b) ½$\hbar\omega$
(c) $\hbar\omega$
(d) ½ $h\omega$

18. The energy of the linear harmonic oscillator at the 1st excited state is
(a) 0
(b) $\frac{1}{2}\hbar\omega$
(c) $\hbar\omega$
(d) $3/2\,\hbar\omega$

19. The Bohr magneton is defined as the magnetic dipole moment associated with an atom due to
(a) orbital motion of an electron in the first stationary orbit
(b) orbital motion of an electron in the first excited state
(c) orbital motion of an electron in presence of magnetic field
(d) electron spin

20. Eigenvectors of $\sigma_x = \begin{pmatrix} 0 & 1 \\ 1 & 0 \end{pmatrix}$ are
(a) $\begin{pmatrix} 1 \\ 0 \end{pmatrix}, \begin{pmatrix} 0 \\ 1 \end{pmatrix}$
(b) $\begin{pmatrix} 1 \\ i \end{pmatrix}, \begin{pmatrix} 1 \\ -i \end{pmatrix}$
(c) $\begin{pmatrix} 1 \\ 1 \end{pmatrix}, \begin{pmatrix} 1 \\ -1 \end{pmatrix}$
(d) $\begin{pmatrix} 1 \\ 0 \end{pmatrix}, \begin{pmatrix} 1 \\ 1 \end{pmatrix}$

21. The angular momentum operator is defined as
(a) $\vec{L} = -i\hbar \vec{r} \times \vec{\nabla}$
(b) $\vec{L} = -i\hbar \vec{r} \times \vec{\nabla}^2$
(c) $\vec{L} = i\hbar \vec{r} \times \vec{\nabla}^2$
(d) $\vec{L} = -i\hbar \vec{\nabla} \times \vec{r}$

22. Two kets $|a\rangle$ and $|b\rangle$ are orthonormal if
(a) $\langle a|b\rangle = 1, \langle b|b\rangle = 1, \langle a|a\rangle = 0$
(b) $\langle a|b\rangle = 0, \langle b|b\rangle = 0, \langle a|a\rangle = 1$
(c) $\langle a|b\rangle = 0, \langle b|b\rangle = 1, \langle a|a\rangle = 1$
(d) $\langle a|b\rangle = 1, \langle b|b\rangle = 1, \langle a|a\rangle = 1$

23. If the inner product between two vectors is zero, then the two vectors are
(a) perpendicular to each other
(b) parallel to each other
(c) magnitude of one vector must be zero
(d) none of the above

24. If $|\psi\rangle$ and $|\phi\rangle$ are vectors in linear vector spaces and a, b are arbitrary complex numbers, then $\langle a\psi | b\phi\rangle$ is equal to
(a) $ab\langle\psi|\phi\rangle$
(b) $a^*b\langle\psi|\phi\rangle$
(c) $a^*b^*\langle\psi|\phi\rangle$
(d) $ab^*\langle\psi|\phi\rangle$

25. If $|\psi_m\rangle$ and $|\psi_n\rangle$ be two eigenvectors having eigenvalues λ_m and λ_n corresponding to the operator $\hat{\alpha}$, then
(a) $\langle\psi_m|\psi_n\rangle = 0$
(b) $\langle\psi_m|\psi_n\rangle = 1$
(c) $\langle\psi_m|\psi_n\rangle = -1$
(d) $\langle\psi_m|\psi_n\rangle \geq 0$

B. Fill up the blanks [15 (3 from each unit)]

1. For a particle of charge *q* , mass *m* moving under a potential difference *V*, the de Broglie wavelength is given by ________________ .
2. For a relativistic particle moving with velocity *v*, the group velocity v_g = ____________
3. The interference of waves associated with a beam of electrons can be demonstrated by means of a ________________ .
4. In 1927 Davisson and Germer demonstrated experimentally and verified de Broglie's relation for the wavelength of an __________.
5. The wave function $\psi(\vec{r},t)$ must be a __________________ and is assumed to represent a plane simple harmonic wave associated with a free particle.
6. The physical meaning of $|\psi(\vec{r},t)|^2$ is the______________ of finding the particle.
7. Two wavefunctions $\psi_1(x)$ and $\psi_2(x)$ are said to be _____________ , if the product of $\psi_1(x)$ and complex conjugate $\psi_2^*(x)$ vanishes when integrated with respect to x over an interval.
8. If a function *f*(*x*) is such that an operator $\hat{A}$ which operates on *f*(*x*) gives $\hat{A}f(x) = a\, f(x)$. Here '*a*' is called the ______________
9. In one dimensional motion: $-\frac{\hbar^2}{2m}\frac{\partial^2}{\partial x^2}$ is the operator for _____________ .
10. For the motion of a particle in an one-dimensional rigid box of side '*a*' , the lowest energy of the particle, called the ground state energy is given by ______________
11. If the force field acting on a particle is zero or nearly zero everywhere except in a limited region, it is said to be a ___________

12. Because of wave nature of matter, there is some probability that the particles penetrates through the barrier to the other side with energy less than the height of the barrier. This probability of crossing the barrier is called the _______________.
13. The ratio (μ_l/L) of magnetic moment to orbital angular momentum of electron is called __________________.
14. The concept of spinning electron was introduced in 1926 by ______________
15. All the Pauli spin matrices are of the order __________

Key Answers:

A. Multiple choice questions

1. (a)	2. (d)	3. (c)	4. (d)	5. (b)	6. (a)	7. (c)
8. (c)	9. (a)	10. (b)	11. (d)	12. (a)	13. (c)	14. (c)
15. (b)	16.(b)	17. (b)	18.(d)	19.(a)	20. (c)	21. (a)
22. (c)	23. (a)	24. (b)	25. (a)			

B. Fill up the blanks:

1. $\lambda = \dfrac{h}{\sqrt{2mqV}}$
2. Particle velocity v
3. double slit experiment
4. electron
5. complex variable quantity
6. probability density.
7. orthogonal

8. eigenvalue
9. kinetic energy
10. $E_1 = \dfrac{h^2}{8ma^2}$
11. Step potential barrier
12. quantum mechanical tunneling effect
13. orbital gyromagnetic ratio
14. Uhlenbeck and Goudsmit
15. 2 x 2.

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