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- **TRB தேர்வில் 100% வெற்றிக்கு எங்களுடைய பயிற்சி வகுப்பிற்கு**(FREE DEMO CLASS) **வருகைதந்துபாருகங்கள் அப்போதுதான் எங்கள் பயிற்சி வகுப்பின் சிறப்பினை அறிய முடியும்**

QUANTUM MECHANICS TEST

Time: 1 Hour Marks: 50

<u>Answer all the questions:</u>
<u>Each questions carries one marks:</u>

1. The eignfunction $\Psi_n(x)$ for a bound state has ______number of nodes if the ground state
corresponds to $n = 0$

a) n b) (n-1) c) (n+1) d) n^2

Solution: A bound state has 'n' number of nodes if the ground state corresponds to $n = 0$ and $(n - 1)$ number of nodes if the ground state corresponds to $n = 1$.

2. Fermi's Golden rule is

a) $\boldsymbol{P = \frac{2\pi}{\hbar}|\langle f|H|i\rangle|^2\rho(E)}$ b) $P = \frac{2\pi}{\hbar}|\langle i|H|f\rangle|^2\rho(E)$

c) $P = \frac{\pi}{\hbar}|\langle f|H|i\rangle|^2\rho(E)$ d) $P = \frac{\pi}{2\hbar}|\langle i|H|f\rangle|^2\rho(E)$

Solution:

Fermi's Golden rule the transition probability per unit time proportional to square of the matrix element connecting the two state and density of the final state

3. Rutherford's differential scattering cross section

a) has the dimensions of area

b) has the dimensions of solid angles

c) is proportional to the kinetic energy of the incident particle

d) inversely proportional to cos φ , φ is the scattering angle

Solution: a

4. The hydrogen atom in a sample are in the excited state corresponding to n=3. number of spectral lines which can be emitted is

a) 1 b) 2 **c) 3** d) 4

Solution: $N = \frac{n(n-1)}{2} = 3$

5. The first excited state of a one dimensional harmonic oscillator has eigen function $\phi(x) = Nxe^{-a^2x^2/2}$, The normalization constant N is

a) $\sqrt{\frac{2a^3}{\sqrt{\pi}}}$ b) $\frac{2a^3}{\sqrt{\pi}}$ c) $\sqrt{\frac{a^2}{\pi}}$ d) $\sqrt{\frac{a}{\sqrt{\pi}}}$

Solution: problem solved in our class notes

6. The uncertainty relation applies to

a) any pair of dynamical variable

b) a pair of dynamical variables, the operators corresponding to which commute

c) pairs of dynamical variable, the operators corresponding to which do not commute

d) x and p_x only

Solution:

The pairs of variables *(E, t)* and *(P_x,x)* are called canonically conjugate pairs of variables.

In quantum mechanics, the operators corresponding to canonically conjugate variables do not commute.

7. What is the uncertainty in Δp_x of the electron confined between boundaries x and $x + \Delta x$ where $\Delta x = 1$ Å then find Δp_y

a) Δp_x b) $3.33 \times 10^{-10} \Delta p_x$

c) Impossible to say d) $0.5 \times 10^{-10} \Delta p_x$

Solution: uncertainty principle applicable for canonically conjugate variables only

8. The value of $\frac{1}{2}(L_-L_- + L - L_+)$ is

a) $L^2 - L_z^2$ b) $L^2 + L_z^2$ c) $L - L_z$ d) $L + L_x$

Solution: Use short KS Academy shortcut method

9. According to Born interpretation $|\Psi|^2\, dx = \Psi^*\Psi\, dx$ is considered as a

a) probability density b) particle density

c) momentum **d) probability**

Solution: IMORTANT QUESTION wrong answer may be chosen by the students

$|\Psi|^2 = \Psi^*\Psi$ is considered as a probability density

$|\Psi|^2\, dx = \Psi^*\Psi\, dx$ is considered as a probability

10. The selection rule for electric dipole transitions of a linear harmonic oscillator is

a) $\Delta n = \pm 1$ b) $\Delta n = 0, \pm 1$

c) $\Delta n = 0, \pm 2$ d) $\Delta n = 0$

Solution:

The selection rule for electric dipole transitions of a linear harmonic oscillator is $\Delta n = \pm 1$

Similarly for hydrogen atoms are $\Delta n =$ any value, $\Delta l = \pm 1$, $\Delta m = 0, \pm 1$

11. For scattering on a hard sphere of radius R, in classical physics the differential scattering cross-section is given by

a) πR^2 b) $\frac{\pi R^2}{2}$ c) $\frac{R^2}{2}$ d) $\frac{R^2}{4}$

Solution: a

12. If a particle is in a spherically symmetric field $V(r)$, the Hamiltonian $\hat{H}$

a) commutes with $\hat{L}^2$ and $\hat{L}_z$

b) does not commute the $\hat{L}^2$ and $\hat{L}_2$

c) commutes only with $\hat{L}^2$ and not with $\hat{L}_z$

d) commutes only with $\hat{L}_z$ and not with $\hat{L}^2$

Solution:

H, L^2, L_Z & S_Z all commute with each other.

13. In Linear Harmonic Oscillator the energy eigen value of second excited state is

a) $\frac{1}{2}\hbar\omega_0$ b) $\frac{3}{2}\hbar\omega_0$ **c) $\frac{5}{2}\hbar\omega_0$** d) $2\hbar\omega_0$

Solution: c

14. Which of the following is correct

a) $Lx = i\hbar\left[\sin\phi\frac{\delta}{\delta\theta} + \cos\theta\cos\phi\frac{\delta}{\delta\theta}\right]$

b) $Lx = i\hbar\left[\cos\phi\frac{\delta}{\delta\theta} + \sin\theta\cos\phi\frac{\delta}{\delta\theta}\right]$

c) $Lx = i\hbar\left[-\sin\phi\frac{\delta}{\delta\theta} + \sin\theta\cos\phi\frac{\delta}{\delta\theta}\right]$

d) $Lx = i\hbar\left[\cos\phi\frac{\delta}{\delta\theta} + \cos\theta\sin\phi\frac{\delta}{\delta\theta}\right]$

Solution:

The angular momentum operator Lx in spherical polar coordinates $Lx = i\hbar\left[\sin\phi\frac{\delta}{\delta\theta} + \cos\theta\cos\phi\frac{\delta}{\delta\theta}\right]$

15. Quantum mechanically, for the ground state of the linear harmonic oscillator ($n = 0$), the probability density becomes zero at position/s

a) $x = 0$ **b) outside the classical turning points**

c) $\pm x$ d) outside the two extreme positions

Solution:

The probability density for ground state of the oscillator ($n = 0$) is maximum at $x = 0$ and becomes zero at positions outside the classical turning points.

16. The position of an electron is measured with an accuracy of 10^{-6} m. The uncertainty in
the electron's position after 1 second is

a) 0.6 m **b) 57.9 m** c) 1.21 m d) 18.5 m

Solution: b

17. According to wave mechanics, a free particle can possess

a) discrete energies b) only one single value of energy

c) continuous energy d) none of these

Solution: c

18. The incident plane wave is equivalent to the superposition of an infinite number of
spherical waves, and the individual spherical waves are called the *partial waves.*
In partial wave analysis individual spherical wave with l = *1*are called

a) s-waves **b) p-waves** c) d-waves d) f-waves

Solution:

In *Partial waves*the incident plane wave is equivalent to the superposition of an infinite number of *spherical waves,* and the individual spherical waves are called the *partial waves.* The waves with *1 = 0, 1, 2, ...* are respectively called the s-waves, p-waves, d-waves, and so on

19. The commutator of the two operators equals

a) Product of two operator b) unity

c) addition of the two operator **d) zero**

Solution:

"commutator" of the two operators equals zero

20. All other operators can be constructed from combinations of these two
The fundamental operators in quantum mechanics is/are

(i) position operator (ii) kinetic energy operator

(iii) momentum operator (iv) Hamiltonian operator

a) iv only b) i & iv

c) i & ii **d) i & iii**

Solution:

All other operators can be constructed from combinations of position & momentum operators.

21. The number of radial nodes in the radial wave function of Hydrogen atom is

a) *n-l-2* b) n+1

c) $n - l - 1$ d) n-1

Solution:

The radial function $R_{nl}(r)$ has $n - l - 1$ radial nodes

22. The commutation relation $[\hat{J}_y, \hat{J}_z] =$

a) $\hat{J}_x$ b) 0 **c) $i\hbar\hat{J}_x$** d) $-2i\hbar\hat{J}_x$

Solution:

Use classical mechanics Poisson bracket short cut

23. Which of the following theorems regarding Hermitian operators are true

(i) The eigenvalues of Hermitian operators are real.

(ii) The eigenfunctions of a Hermitian operator that belong to different eigen values are orthogonal.

a) i only b) ii only

c) i & ii d) none of the above

Solution: **In matrix unit the answer will be explained in detail**

24. The operators corresponding to canonically conjugate variables

a) commute b) not commute

c) either commute or not commute d) none of the above

Solution: **a**

25. Which of the following represents first order correction to the wave function in Non –
degenerate perturbation theory

a) $|\psi_1\rangle = \sum_k \frac{\langle k|H'|m\rangle}{(E_m - E_k)}|k\rangle$ b) $|\psi_1\rangle = \sum_m \frac{\langle k|H'|m\rangle}{(E_k - m)}|k\rangle$

c) $|\psi_1\rangle = \sum_k \frac{\langle k|H'|m\rangle}{(E_m + E_k)}|k\rangle$ d) $|\psi_1\rangle = \sum_m \frac{\langle k|H'|m\rangle}{(E_k - E_m)}|k\rangle$

Solution: a

26. The ground state of the harmonic wave function is

a) $\Psi_0(x) = \left(\frac{m\omega}{\hbar\pi}\right)^{1/4} exp\left[\frac{-m\omega x^2}{2\hbar}\right]$ b) $\Psi_0(x) = \left(\frac{\hbar\pi}{m\omega}\right)^{1/4} exp\left[\frac{-m\omega x^2}{2\hbar}\right]$

c) $\Psi_0(x) = \left(\frac{m\omega}{\hbar\pi}\right)^{1/2} exp\left[\frac{-m^2\omega^2 x^2}{2\hbar^2}\right]$ d) $\Psi_0(x) = \left(\frac{\hbar\pi}{m\omega}\right)^{1/2} exp\left[\frac{-m^2\omega^2 x^2}{2\hbar^2}\right]$

27. The de-Broglie wavelength λ for an electron of energy 150 eV is

a) $10^{-8}\ m$ **b) $10^{-10} m$** c) $10^{-12}\ m$ d) $10^{-14}\ m$

Solution:

Use short cut method

28. If $sin2x$ is the eigen function then the eigen value of the operator $\frac{-d^2}{dx^2}$ would be given by.

a) 2 b) 3 **c) 4** d) 8

Solution: problem solved in our class notes

29. The commutator of $[x,\ {p_x}^2]$ is

a) $2\hbar \frac{d}{dx}$ b) $i\hbar$ **c) $2\hbar^2 \frac{d}{dx}$** d) $-i\hbar$

Solution: Use KS Academy short cut method

30. The average momentum of a particle in a box of width a is

a) zero b) p/2

c) p/a d) p

Solution:

The average momentum of a particle in a box is zero.

31. The average value of the position ($<r>$) for the particle in a 3D box is

a) center of one face of the cube
b) exactly at center of the cube
c) one edge of the cube
d) outside the cube

Solution: Use KS Academy short cut method

32. The strongest IR absorption band of $12_C 16_O$ molecule occurs at $6.43 \times 10^{13}\ Hz$. If the reduced mass of $12_C 16_O$ is $1.385 \times 10^{-26} kg$, The approximate zero point energy is

a) 0 eV
b) 2.5 eV
c) 2.5 MeV
d) 0.133 eV

Solution: Problem solved in our class notes

33. Find the Odd one out

a) (2,1,1)
b) (1,1,2)
c) (1,2,1)
d) (1,1,1)

Solution:
(1,1,1) is Non-degenerate in 3D infinte box all other are degenerate state (2,1,1) (1,1,2) & (1,2,1)

34. The probability current density can be written as

a) $\boldsymbol{S\ (r,t) = \frac{h}{2im}\ (\psi * \nabla\psi - \psi\nabla\psi\ *)}$
b) $S\ (r,t) = real\ part\ of\ \psi * \frac{h}{m}\ \psi$
c) $S\ (r,t) = imaginary\ part\ of\ \psi * \frac{h}{m}\ \psi$
d) $S\ (r,t) = \frac{h}{2m}\ \psi * \ \nabla\psi$

Solution: a

35. Fir Gaussian wavefunction $\psi\ (x) = Ne^{-x^{2}/2\sigma^2}, -\infty < x < \infty$, the value of N is

a) $\frac{1}{\sqrt{\pi}}$
b) $\frac{1}{\sqrt{2\pi}}$
c) $\boldsymbol{\frac{1}{\sqrt{3\pi}}}$
d) $\frac{2}{\sqrt{\pi}}$

Solution: Problem solved in our class notes

36. The result of raising operator a^+ operating on the wave function $\text{I}n\rangle$ is

a) $\sqrt{n+1}\ \ \text{I}n\rangle$
b) $\boldsymbol{\sqrt{n+1}\ \ \text{I}n+1\rangle}$
c) $\sqrt{n+1}\ \ \text{I}n-1\rangle$
d) $\sqrt{n+1}\ \ \text{I}n+2\rangle$

Solution: Problem solved in our class notes

37. The energy of a rigid rotator is

a) discrete and not continuous.

b) discrete and continuous.

c) not discrete and continuous.

d) none of the above

Solution:

The energy of a rigid rotator is $E = \frac{1}{2}\frac{n^2\hbar^2}{I}$

So Energy is discrete and not continuous.

38. A particle of mass m is represented by the wavefunction $\psi(x) = Ae^{ikx}$, where k is the wave vector and A is constant. The magnitude of the probability current density of the particle is

a) $|\boldsymbol{A}|^2 \frac{\boldsymbol{hk}}{\boldsymbol{m}}$

b) $|A|^2 \frac{hk}{2m}$

c) $|A|^2 \frac{(hk)^2}{m}$

d) $|A|^2 \frac{(hk)^2}{2m}$

Solution: Problem solved in our class notes

39. The commutator of two Hermitian operators is

a) hermitian

b) inverse operator

c) antihermitian

d) does not exists

Solution: c

40. The degeneracy of the energy eigenstate of the three-dimensional isotropic oscillator is

a) $\frac{\boldsymbol{1}}{\boldsymbol{2}}(\boldsymbol{n}+\boldsymbol{1})(\boldsymbol{n}+\boldsymbol{2})$

b) n^2

c) $\frac{1}{2}(n-1)(n-2)$

d) $(n+1)$

Solution: a

41. According to a *state-vector* in a complex vector-space is represented by a

a) *bra vector*

b) ket vector

c) bra & *ket vector*

d) normal vector

Solution:

According to Dirac, a *state-vector* in a complex vector-space is a *ket vector* or simply a *ket*

42. 1s state wave function of the hydrogen atom is given by $\Psi_{1s} = Nexp(-\frac{r}{a_0})$ What is the value of N?

a) $\frac{1}{a_0^3}$ b) $\frac{\pi}{a_0^3}$ **c)** $\frac{1}{\sqrt{\pi a_0^3}}$ d) $\sqrt{\frac{\pi}{a_0^3}}$

Solution: Problem solved in our class notes

43. The radial and angular wave function gives

a) Shape, orientation and energy, size of the orbitals respectively

b) energy, size and shape, orientation of the orbitals respectively

c) Energy and size of the orbitals respectively

d) Shape and orientation of the orbitals respectively

Solution:

Radial part of the wave function gives energy, size of the orbit

Angular part of the wave function gives shape, orientation of the orbit

44. Time dependent Schrodinger wave equation is not relativistically invariant, since

a) It has first derivative in time

b) Second derivative in space coordinates

c) It is relativistically invariant

d) Both a and b

Solution:

The Schrödinger equation is not Lorentz invariant(not relativistically invariant). This is due to the occurrence of one time derivative but two space derivatives in the equation.

Dirac constructing a relativistic wave equation(relativistically invariant)

45. The spin angular momentum component of the operator S_x in matrix form is

a) $\frac{\hbar}{2}\begin{bmatrix}1 & 0\\0 & 1\end{bmatrix}$ b) $\frac{\hbar}{2}\begin{bmatrix}0 & 1\\-1 & 0\end{bmatrix}$

c) $\frac{i\hbar}{2}\begin{bmatrix}0 & -1\\1 & 0\end{bmatrix}$ d) $\frac{\hbar}{2}\begin{bmatrix}1 & 0\\0 & -1\end{bmatrix}$

Solution: Use KS Academy short cut method

46. The magnitude of the orbital angular momentum **L** of a hydrogen atom is $\sqrt{30}$ ħ and L_Z is 3ħ.The value of ${L_X}^2 + {L_Y}^2$ =?

a) 21 $\hbar^2$ b) 36$\hbar^2$ c) 1.2 $\hbar^2$ d) 6$\hbar^2$

Solution:

$L^2 = 30\hbar^2$

$L_x^2 + L_y^2 = L^2 - L_z^2 = (30 - 9)\hbar^2 = 21\hbar^2$.

47. Which of the following is an indication of quantum mechanics?

a) Even stationary particles have wave behaviours

b) Only moving particles have wave behavirours

c) Only charged particles have wave behavirous

d) None of above

Solution:

Electromagnetic radiation could not only a wave, but also as a stream of particles—later termed photons. In the same way wave moving particles, could behave like waves. This concept is now known as"wave-particle duality".

48. Let E_n denote the energy of the n^{th} excited state for a particle trapped in 1 dim. box ∞ height, then E_n varies with quantum number is

a) $\frac{1}{n}$ b) n c) $\frac{1}{n^2}$ **d) n^2**

Solution: $E = \frac{n^2\hbar^2\pi^2}{2mL^2}$

$E_n \propto n^2$ $E = \frac{n^2 h^2}{8mL^2}$ $n = 1, 2, 3, \dots \dots$

49. If a is the operator, operating on a state function ψ, then the possible values of any physical quantity of a system (e.g., energy, angular momentum, etc.) in the operator equation $A\psi = a\psi$ are given by

a) Eigen functions ψ

b) Eigen values 'a'

c) eigen value 'a' as well as eigen function ψ

d) None of the above is correct

Solution:

$$A\psi = a\psi$$

The wave function ψ that satisfies above equation is known as eigen function and corresponding observable quantity "a" is known as eigen value.

50. Which of the following is not acceptable wave function in quantum mechanics-

a) $sin^2 x$ **b) $\boldsymbol{cosec\ x}$** c) $\sin x + \cos x$ d) e^{ix}

Solution: Problem solved in our class notes

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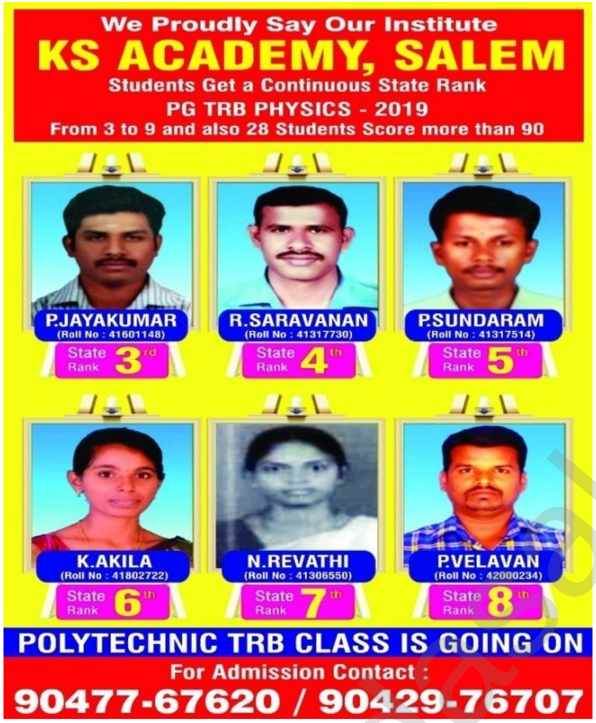

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