PhysicsByAaryan

CSIR NET . GATE . JEST . BARC - Physics

Orbital angular Momentum and Hydrogen atom - CSIR NET Physics PYQs

Quantum Mechanics . All PYQs (2015-2025) with answer key

24 questions . Answer key included

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Q1. [Dec 2015] . 3.5 marks

Quantum Mechanics > Orbital angular Momentum and Hydrogen atom

CSIR NET	2015 Dec	3.5 M

Let ψ_{nlm} denote the eigenstates of a hydrogen atom in the usual notation. The state

$$\frac{1}{5}\left[2\psi_{200} - 3\psi_{211} + \sqrt{7}\psi_{210} - \sqrt{5}\psi_{21-1}\right]$$

is an eigenstate of

1. L^2, but not of the Hamiltonian or L_z
2. the Hamiltonian, but not of L^2 or L_z
3. the Hamiltonian, L^2 and L_z
4. L^2 and L_z, but not of the Hamiltonian

Q2. [Dec 2015] . 5.0 marks

Quantum Mechanics > Orbital angular Momentum and Hydrogen atom

CSIR NET	2015 Dec	5 M

A positron is suddenly absorbed by the nucleus of a tritium (^3_1H) atom to turn the latter into a He^+ ion. If the electron in the tritium atom was initially in the ground state, the probability that the resulting He^+ ion will be in its ground state is

1. 1
2. $\frac{8}{9}$
3. $\frac{128}{243}$
4. $\frac{512}{729}$

Q3. [Dec 2015] . 5.0 marks

Quantum Mechanics > Orbital angular Momentum and Hydrogen atom

CSIR NET	2015 Dec	5 M

The product of the uncertainties $(\Delta L_x)(\Delta L_y)$ for a particle in the state $a|1,1\rangle + b|1,-1\rangle$ where $|l,m\rangle$ denotes an eigenstate of L^2 and L_z will be a minimum for

1. $a = \pm ib$
2. $a = 0$ and $b = 1$
3. $a = \frac{\sqrt{3}}{2}$ and $b = \frac{1}{2}$
4. $a = \pm b$

Q4. [June 2015] . 3.5 marks

Quantum Mechanics > Orbital angular Momentum and Hydrogen atom

CSIR NET	2015 June	3.5 M

If L_i are the components of the angular momentum operator $\vec{L}$, then the operator $\sum_{i=1,2,3}\left[\left[\vec{L}, L_i\right], L_i\right]$ equals

1. $\vec{L}$
2. $2\vec{L}$
3. $3\vec{L}$
4. $-\vec{L}$

Q5. [June 2016] . 3.5 marks

Quantum Mechanics > Orbital angular Momentum and Hydrogen atom

CSIR NET	2016 June	3.5M

If $\hat{L}_x, \hat{L}_y$ and $\hat{L}_z$ are the components of the angular momentum operator in three dimensions, the commutator $[\hat{L}_x, \hat{L}_x\hat{L}_y\hat{L}_z]$ may be simplified to

1. $i\hbar L_x(\hat{L}_z^2 - \hat{L}_y^2)$
2. $i\hbar\hat{L}_z\hat{L}_y\hat{L}_x$
3. $i\hbar L_x(2\hat{L}_z^2 - \hat{L}_y^2)$
4. 0

Q6. [June 2016] . 3.5 marks

Quantum Mechanics > Orbital angular Momentum and Hydrogen atom

CSIR NET	2016 June	3.5M

Suppose that the Coulomb potential of the hydrogen atom is changed by adding an inverse-square term such that the total potential is $V(\vec{r}) = -\frac{Ze^2}{r} + \frac{g}{r^2}$, where g is a constant. The energy eigenvalues E_{nlm} in the modified potential

1. depend on n and l, but not on m
2. depend on n but not on l and m
3. depend on n and m, but not on l
4. depend explicitly on all three quantum numbers n, l and m

Q7. [Dec 2017] . 3.5 marks

Quantum Mechanics > Orbital angular Momentum and Hydrogen atom

CSIR NET	2017 Dec	3.5M

The normalized wavefunction of a particle in three dimensions is given by $\psi(r,\theta,\varphi) = \frac{1}{\sqrt{8\pi a^3}} e^{-r/2a}$ where $a > 0$ is a constant. The ratio of the most probable distance from the origin to the mean distance from the origin, is

[You may use $\int_0^\infty dx x^n e^{-x} = n!$]

1. $\frac{1}{3}$
2. $\frac{1}{2}$
3. $\frac{3}{2}$
4. $\frac{2}{3}$

Q8. [Dec 2018] . 3.5 marks

Quantum Mechanics > Orbital angular Momentum and Hydrogen atom

CSIR NET	2018 Dec	3.5M

Let the wavefunction of the electron in a hydrogen atom be

$$\psi(\vec{r}) = \frac{1}{\sqrt{6}}\phi_{200}(\vec{r}) + \sqrt{\frac{2}{3}}\phi_{21-1}(\vec{r}) - \frac{1}{\sqrt{6}}\phi_{100}(\vec{r})$$

where $\phi_{nlm}(\vec{r})$ are the eigenstates of the Hamiltonian in the standard notation. The expectation value of the energy in this state is

1. -10.8 eV
2. -6.2 eV
3. -9.5 eV
4. -5.1 eV

Q9. [Dec 2018] . 5.0 marks

Quantum Mechanics > Orbital angular Momentum and Hydrogen atom

CSIR NET	2018 Dec	5M

Consider the operator $A_x = L_y p_z - L_z p_y$, where L_i and p_i denote, respectively, the components of the angular momentum and momentum operators. The commutator $[A_x, x]$, where x is the x - component of the position operator, is

1. $-i\hbar(zp_z + yp_y)$
2. $-i\hbar(zp_z - yp_y)$
3. $i\hbar(zp_z + yp_y)$
4. $i\hbar(zp_z - yp_y)$

Q10. [Dec 2018] . 5.0 marks

Quantum Mechanics > Orbital angular Momentum and Hydrogen atom

CSIR NET	2018 Dec	5M

If the position of the electron in the ground state of a Hydrogen atom is measured, the probability that it will be found at a distance $r \geq a_0$ (a_0 being Bohr radius) is nearest to

1. 0.91
2. 0.66
3. 0.32
4. 0.13

Q11. [Dec 2019] . 3.5 marks

Quantum Mechanics > Orbital angular Momentum and Hydrogen atom

CSIR NET	2019 Dec	3.5M

The normalized wavefunction of a particle in three dimensions is given by

$$\psi(x, y, z) = Nz\exp\left[-a\left(x^2 + y^2 + z^2\right)\right]$$

where a is a positive constant and N is a normalization constant. If L is the angular momentum operator, the eigenvalues of L^2 and L_z, respectively, are

1. $2\hbar^2$ and $\hbar$
2. $\hbar^2$ and 0
3. $2\hbar^2$ and 0
4. $\frac{3}{4}\hbar^2$

Q12. [Dec 2019] . 5.0 marks

Quantum Mechanics > Orbital angular Momentum and Hydrogen atom

CSIR NET	2019 Dec	5M

The wavefunction of a particle of mass m, constrained to move on a circle of unit radius cantered at the origin in the xy - plane, is described by $\psi(\phi) = A\cos^2\phi$, where ϕ is the azimuthal angle. All the possible outcomes of measurements of the z - component of the angular momentum L_z in this state, in units of $\hbar$ are

1. ± 1 and 0
2. ± 1
3. ± 2
4. ± 2 and 0

Q13. [June 2019] . 3.5 marks

Quantum Mechanics > Orbital angular Momentum and Hydrogen atom

CSIR NET	2019 June	3.5M

A particle moving in a central potential is described by a wave function $\psi(r) = zf(r)$ where $r = (x, y, z)$ is the position vector of the particle and $f(r)$ is a function of $r = |r|$. If L is the total angular momentum of the particle, the value of L^2 must be

1. $2\hbar^2$
2. $\hbar^2$
3. $4\hbar^2$
4. $\frac{3}{4}\hbar^2$

Q14. [June 2020] . 3.5 marks

Quantum Mechanics > Orbital angular Momentum and Hydrogen atom

CSIR NET	2020 June	3.5M

An angular momentum eigenstate $|j, 0\rangle$ is rotated by an infinitesimally small angle ε about the positive y-axis in the counter clockwise direction. The rotated state, to order ε (upto a normalisation constant), is

1. $|j, 0\rangle - \frac{\varepsilon}{2}\sqrt{j(j+1)}(|j, 1\rangle + |j, -1\rangle)$
2. $|j, 0\rangle - \frac{\varepsilon}{2}\sqrt{j(j+1)}(|j, 1\rangle - |j, -1\rangle)$
3. $|j, 0\rangle - \frac{\varepsilon}{2}\sqrt{j(j-1)}(|j, 1\rangle - |j, -1\rangle)$
4. $|j, 0\rangle - \frac{\varepsilon}{2}\sqrt{j(j+1)}|j, 1\rangle - \frac{\varepsilon}{2}\sqrt{j(j-1)}|j, -1\rangle$

Q15. [June 2020] . 5.0 marks

Quantum Mechanics > Orbital angular Momentum and Hydrogen atom

CSIR NET	2020 June	5M

The state of an electron in a hydrogen atom is

$$|\psi\rangle = \frac{1}{\sqrt{6}}|1,0,0\rangle + \frac{1}{\sqrt{3}}|2,1,0\rangle + \frac{1}{\sqrt{2}}|3,1,-1\rangle$$

where $|n, l, m\rangle$ denotes common eigenstates of $\hat{H}, \hat{L}^2$ and $\hat{L}_z$ operators in the standard notation.

In a measurement of $\hat{L}_z$ for the electron in this state, the result is recorded to be 0 . Subsequently a measurement of energy is performed. The probability that the result is E_2 (the energy of the $n = 2$ state) is

1. 1
2. $1/2$
3. $2/3$
4. $1/3$

Q16. [June 2021] . 3.5 marks

Quantum Mechanics > Orbital angular Momentum and Hydrogen atom

CSIR NET	2021 June	3.5M

Which of the following two physical quantities cannot be measured simultaneously with arbitrary accuracy for the motion of a quantum particle in three dimensions?

1. square of the radial position and z-component of angular momentum (r^2 and L_z)
2. x-components of linear and angular momenta (p_x and L_x)
3. x-components of linear and angular momenta (p_x and L_x)
4. squares of the magnitudes of the linear and angular momenta (p^2 and L^2)

Q17. [Dec 2023] . 3.5 marks

Quantum Mechanics > Orbital angular Momentum and Hydrogen atom

CSIR NET	2023 Dec	3.5 M

The Schrodinger wave function for a stationary state of an atom in spherical polar coordinates (r, θ, ϕ) is

$$\psi = Af(r)\sin\theta\cos\theta e^{i\phi}$$

where A is the normalization constant. The eigenvalue of $\hat{L}_z$ for this state is

1. $2\hbar$
2. $\hbar$
3. $-2\hbar$
4. $-\hbar$

Q18. [Dec 2023] . 3.5 marks

Quantum Mechanics > Orbital angular Momentum and Hydrogen atom

CSIR NET	2023 Dec	3.5 M

The Hamiltonian for two particles with angular momentum quantum numbers $l_1 = l_2 = 1$, is

$$\hat{H} = \frac{\epsilon}{\hbar^2}\left[\left(\hat{L}_1 + \hat{L}_2\right)\cdot \hat{L}_2 - \left(\hat{L}_{1z} + \hat{L}_{2z}\right)^2\right]$$

If the operator for the total angular momentum is given by $\hat{L} = \hat{L}_1 + \hat{L}_2$, then the possible energy eigenvalues for states with $l = 2$, (where the eigenvalues of $\hat{L}^2$ are $l(l+1)h^2$) are

1. $3\in, 2\in, -\in$
2. $6\in, 5\in, 2\in$
3. $3\in, 2\in, \in$
4. $-3\in, -2\in, \in$

Q19. [June 2023] . 3.5 marks

Quantum Mechanics > Orbital angular Momentum and Hydrogen atom

CSIR NET	2023 June	3.5M

The value of $\langle L_x^2\rangle$ in the state $|\varphi\rangle$ for which $L^2|\varphi\rangle = 6\hbar^2|\varphi\rangle$ and $L_z|\varphi\rangle = 2\hbar|\varphi\rangle$, is

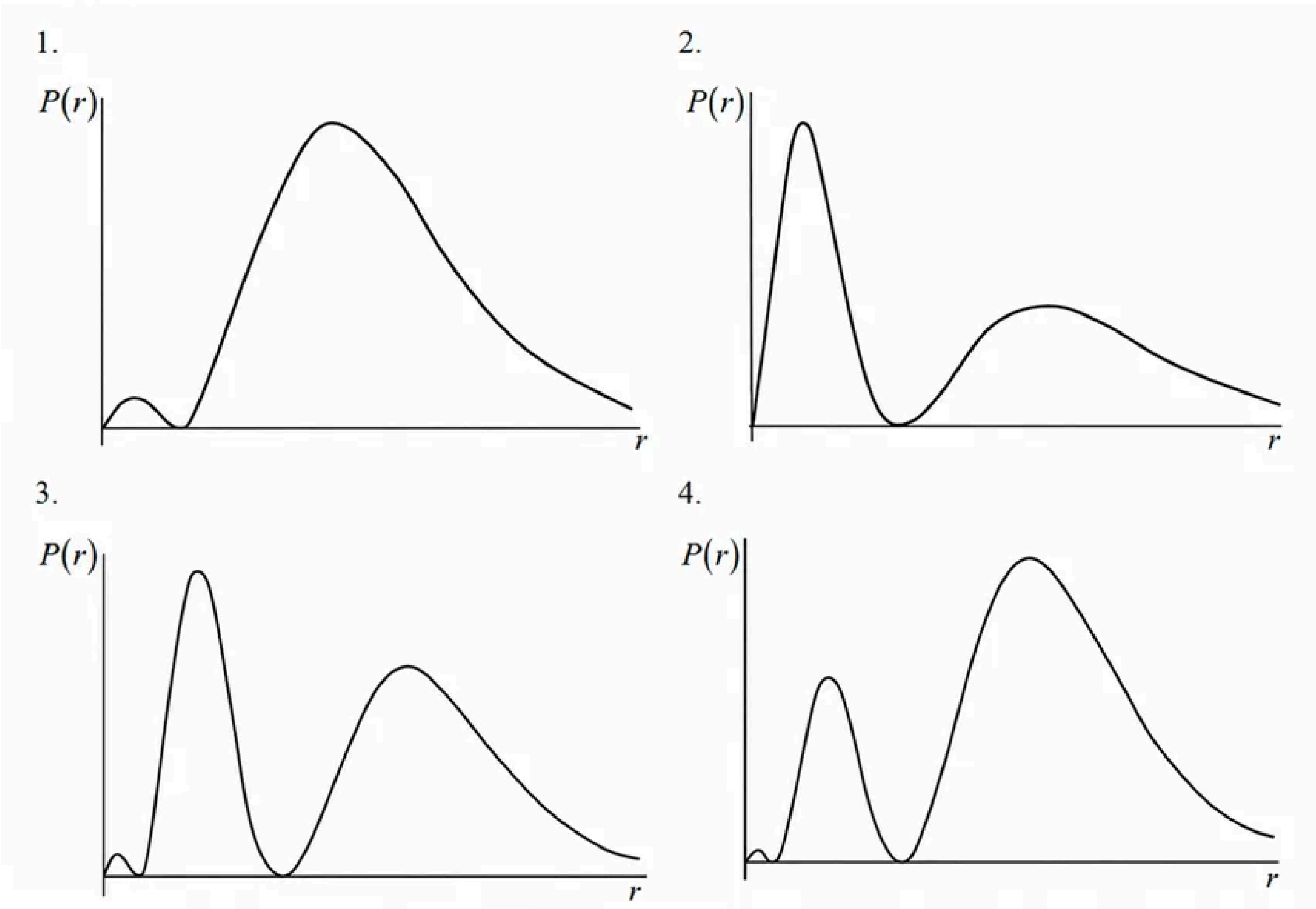
1. 0
2. $4\hbar^2$
3. $2\hbar^2$
4. $\hbar^2$

Q20. [June 2023] . 3.5 marks

Quantum Mechanics > Orbital angular Momentum and Hydrogen atom

CSIR NET	2023 June	3.5M

The radial wavefunction of hydrogen atom with the principal quantum number $n = 2$ and the orbital quantum number $\ell = 0$ is $R_{20} = N\left(1 - \frac{r}{2a}\right)e^{-\frac{r}{2a}}$, where N is the normalization constant. The best schematic representation of the probability density $P(r)$ for the electron to be between r and $r + dr$ is



Q21. [June 2024] . 3.5 marks

Quantum Mechanics > Orbital angular Momentum and Hydrogen atom

CSIR NET	2024 June	3.5M

A quantum mechanical system is in the angular momentum state $|l = 4, l_z = 4\rangle$. The uncertainty in L_x is

1. $\hbar\sqrt{2}$
2. $2\hbar$
3. 0
4. $\hbar$

Q22. [June 2024] . 3.5 marks

Quantum Mechanics > Orbital angular Momentum and Hydrogen atom

CSIR NET	2024 June	3.5M

A hydrogen atom is in the state

$$|\psi\rangle = \sqrt{\frac{8}{21}}|\psi_{200}\rangle + \sqrt{\frac{3}{7}}|\psi_{210}\rangle + \sqrt{\frac{4}{21}}|\psi_{311}\rangle$$

where $|\psi_{nlm}\rangle$ are normalised eigenstates. If $\hat{L}^2$ is measured in this state, the probability of obtaining the value $2\hbar^2$ is

1. $\frac{13}{21}$
2. $\frac{4}{21}$
3. $\frac{17}{21}$
4. $\frac{3}{7}$

Q23. [Dec 2025] . 3.5 marks

Quantum Mechanics > Orbital angular Momentum and Hydrogen atom

CSIR NET	2025 Dec	3.5M	QM

If $\vec{\hat{L}}$ is the angular momentum operator for a quantum particle, then $\vec{\hat{L}} \times \vec{\hat{L}}$ is

1. $\hbar^2$
2. $-i\hbar\vec{\hat{L}}$
3. 0
4. $i\hbar\vec{\hat{L}}$

Q24. [Dec 2025] . 5.0 marks

Quantum Mechanics > Orbital angular Momentum and Hydrogen atom

CSIR NET	2025 Dec	5M	QM

For a particle in the angular momentum state $|l = 4, m_l = 2\rangle$, the expectation value of the operator $L_x L_y$ is

1. $-\hbar^2$
2. $\hbar^2$
3. $-i\hbar^2$
4. $i\hbar^2$

Answer Key

24 questions . Subject and topic for quick revision

Q. No	Subject	Topic	Answer
Q1	Quantum Mechanics	Orbital angular Momentum and Hydrogen atom	**2**
Q2	Quantum Mechanics	Orbital angular Momentum and Hydrogen atom	**4**
Q3	Quantum Mechanics	Orbital angular Momentum and Hydrogen atom	**4**
Q4	Quantum Mechanics	Orbital angular Momentum and Hydrogen atom	**2**
Q5	Quantum Mechanics	Orbital angular Momentum and Hydrogen atom	**1**
Q6	Quantum Mechanics	Orbital angular Momentum and Hydrogen atom	**1**
Q7	Quantum Mechanics	Orbital angular Momentum and Hydrogen atom	**4**
Q8	Quantum Mechanics	Orbital angular Momentum and Hydrogen atom	**4**
Q9	Quantum Mechanics	Orbital angular Momentum and Hydrogen atom	**1**
Q10	Quantum Mechanics	Orbital angular Momentum and Hydrogen atom	**2**
Q11	Quantum Mechanics	Orbital angular Momentum and Hydrogen atom	**3**
Q12	Quantum Mechanics	Orbital angular Momentum and Hydrogen atom	**4**
Q13	Quantum Mechanics	Orbital angular Momentum and Hydrogen atom	**1**
Q14	Quantum Mechanics	Orbital angular Momentum and Hydrogen atom	**2**
Q15	Quantum Mechanics	Orbital angular Momentum and Hydrogen atom	**3**
Q16	Quantum Mechanics	Orbital angular Momentum and Hydrogen atom	**3**
Q17	Quantum Mechanics	Orbital angular Momentum and Hydrogen atom	**2**
Q18	Quantum Mechanics	Orbital angular Momentum and Hydrogen atom	**1**
Q19	Quantum Mechanics	Orbital angular Momentum and Hydrogen atom	**4**
Q20	Quantum Mechanics	Orbital angular Momentum and Hydrogen atom	**1**
Q21	Quantum Mechanics	Orbital angular Momentum and Hydrogen atom	**1**
Q22	Quantum Mechanics	Orbital angular Momentum and Hydrogen atom	**1**
Q23	Quantum Mechanics	Orbital angular Momentum and Hydrogen atom	**4**
Q24	Quantum Mechanics	Orbital angular Momentum and Hydrogen atom	**4**

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