PhysicsByAaryan

CSIR NET . GATE . JEST . BARC - Physics

Quantum Harmonic Oscillator - CSIR NET Physics PYQs

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

10 questions . Answer key included

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Q1. [Dec 2016] . 3.5 marks

Quantum Mechanics > Quantum Harmonic Oscillator

CSIR NET	2016 Dec	3.5M

Let $a = \frac{1}{\sqrt{2}}(x + ip)$ and $a^\dagger = \frac{1}{\sqrt{2}}(x - ip)$ be the lowering and raising operators of a simple harmonic oscillator in units where the mass, angular frequency and $\hbar$ have been set to unity. If $|0\rangle$ is the ground state of the oscillator and λ is a complex constant, the expectation value of $\langle\psi|x|\psi\rangle$ in the state $|\psi\rangle = \exp\left(\lambda a^\dagger - \lambda^* a\right)|0\rangle$, is

1. $|\lambda|$

2. $\sqrt{|\lambda|^2 + \frac{1}{|\lambda|^2}}$

3. $\frac{1}{\sqrt{2}i}(\lambda - \lambda^*)$

4. $\frac{1}{\sqrt{2}}(\lambda + \lambda^*)$

Q2. [June 2017] . 3.5 marks

Quantum Mechanics > Quantum Harmonic Oscillator

CSIR NET	2017 June	3.5M

If the root-mean-squared momentum of a particle in the ground state of a one-dimensional simple harmonic potential is p_0, then its root-mean-squared momentum in the first excited state is

1. $p_0\sqrt{2}$
2. $p_0\sqrt{3}$
3. $p_0\sqrt{2/3}$
4. $p_0\sqrt{3/2}$

Q3. [Dec 2018] . 3.5 marks

Quantum Mechanics > Quantum Harmonic Oscillator

CSIR NET	2018 Dec	3.5M

The ground state energy of an anisotropic harmonic oscillator described by the potential

$$V(x,y,z) = \frac{1}{2}m\omega^2x^2 + 2m\omega^2y^2 + 8m\omega^2z^2$$

(in units of $\hbar\omega$) is

1. $\frac{5}{2}$
2. $\frac{7}{2}$
3. $\frac{3}{2}$
4. $\frac{1}{2}$

Q4. [Dec 2018] . 3.5 marks

Quantum Mechanics > Quantum Harmonic Oscillator

CSIR NET	2018 Dec	3.5M

The product $\Delta x \Delta p$ of uncertainties in the position and momentum of a simple harmonic oscillator of mass m and angular frequency ω in the ground state $|0\rangle$, is $\frac{\hbar}{2}$. The value of the product $\Delta x \Delta p$ in the state, $e^{-i\hat{p}\ell/\hbar}|0\rangle$ (where ℓ is a constant and $\hat{p}$ is the momentum operator) is

1. $\frac{\hbar}{2}\sqrt{\frac{m\omega\ell^2}{\hbar}}$
2. $\hbar$
3. $\frac{\hbar}{2}$
4. $\frac{\hbar^2}{m\omega\ell^2}$

Q5. [June 2023] . 3.5 marks

Quantum Mechanics > Quantum Harmonic Oscillator

CSIR NET	2023 June	3.5M

The Hamiltonian of a two-dimensional quantum harmonic oscillator is

$$H = \frac{p_x^2}{2m} + \frac{p_y^2}{2m} + \frac{1}{2}m\omega^2x^2 + 2m\omega^2y^2$$

where m and ω are positive constants. The degeneracy of the energy level $\frac{27}{2}\hbar\omega$ is

1. 14
2. 13
3. 8
4. 7

Q6. [Dec 2024] . 5.0 marks

Quantum Mechanics > Quantum Harmonic Oscillator

CSIR NET	2024 Dec	5M

Eigenstates of a system are specified by two non negative integers n_1 and n_2. The energy of the system is given by

$$E_n = \left(n_1 + \frac{1}{2}\right)\hbar\omega + \left(n_2 + \frac{1}{2}\right)2\hbar\omega.$$

If $\alpha \equiv \exp\left(-\frac{\hbar\omega}{k_B T}\right)$, what is the probability that at temperature T the energy of the system will be less than $4\hbar\omega$?

1. $(1-\alpha^2)(1-\alpha)(2+\alpha+2\alpha^2)$
2. $(1-\alpha)^2(1-\alpha)(2+\alpha+\alpha^2)$
3. $(1-\alpha^2)(1+\alpha)(1+\alpha+2\alpha^2)$
4. $(1-\alpha)^2(1+\alpha)(1+\alpha+2\alpha^2)$

Q7. [June 2024] . 3.5 marks

Quantum Mechanics > Quantum Harmonic Oscillator

CSIR NET	2024 June	3.5M

The Hamiltonian for a one-dimensional simple harmonic oscillator is given by $H = \frac{p^2}{2m} + \frac{1}{2}m\omega^2 x^2$. The harmonic oscillator is in the state

$$|\psi\rangle = \frac{1}{\sqrt{1+\lambda^2}}\left(|1\rangle + \lambda e^{i\theta}|2\rangle\right),$$

where $|1\rangle$ and $|2\rangle$ are the normalised first and second excited states of the oscillator and λ, θ are positive real constants. If the expectation value $\langle\psi|x|\psi\rangle = \beta\sqrt{\frac{\hbar}{m\omega}}$, the value of β is

1. $\frac{1}{\sqrt{2}(1+\lambda^2)}$
2. $\frac{\sqrt{2}\lambda\cos\theta}{1+\lambda^2}$
3. $\frac{2\lambda\cos\theta}{1+\lambda^2}$
4. $\frac{\lambda^2\cos\theta}{1+\lambda^2}$

Q8. [Dec 2025] . 3.5 marks

Quantum Mechanics > Quantum Harmonic Oscillator

CSIR NET	2025 Dec	3.5M	QM

A quantum particle of mass m is moving in a potential

$$V(x,y) = \frac{m\omega^2}{8}\left[5(x^2 + y^2) + 8xy\right].$$

The lowest energy eigenstate with degeneracy has an energy

1. $\frac{7}{2}\hbar\omega$
2. $\frac{3}{2}\hbar\omega$
3. $4\hbar\omega$
4. $\frac{5}{2}\hbar\omega$

Q9. [June 2025] . 3.5 marks

Quantum Mechanics > Quantum Harmonic Oscillator

CSIR NET	2025 June	3.5M	QM

The energy eigenstates of a one-dimensional harmonic oscillator are denoted by $|i\rangle$, where $i = 0,1,2,3 \ldots.$. If the momentum operator $\hat{p}$ satisfies $\frac{\langle n+1|\hat{p}|n\rangle}{\langle 2|\hat{p}|1\rangle} = \sqrt{2}$, then the value of n is

1. 0
2. 1
3. 2
4. 3

Q10. [June 2025] . 5.0 marks

Quantum Mechanics > Quantum Harmonic Oscillator

CSIR NET	2025 June	5M	QM

$|n\rangle$ denotes the eigenvector of the number operator for a particle of mass m in a one-dimensional potential $V = \frac{1}{2}m\omega^2 x^2 (n = 0,1,2,\cdots)$. For the state vector $|\varphi(x, t = 0)\rangle = \frac{1}{\sqrt{3}}|1\rangle + \sqrt{\frac{2}{3}}|2\rangle$, $\langle\hat{x}(t)\rangle$ is

1. $\frac{2\sqrt{2}}{3}\sqrt{\frac{\hbar}{2m\omega}}\cos\omega t$
2. $\frac{4}{3}\sqrt{\frac{\hbar}{2m\omega}}\cos\omega t$
3. $\frac{2\sqrt{2}}{3}\sqrt{\frac{\hbar}{2m\omega}}\cos 2\omega t$
4. $\frac{4}{3}\sqrt{\frac{\hbar}{2m\omega}}\cos 2\omega t$

Answer Key

10 questions . Subject and topic for quick revision

Q. No	Subject	Topic	Answer
Q1	Quantum Mechanics	Quantum Harmonic Oscillator	**4**
Q2	Quantum Mechanics	Quantum Harmonic Oscillator	**2**
Q3	Quantum Mechanics	Quantum Harmonic Oscillator	**2**
Q4	Quantum Mechanics	Quantum Harmonic Oscillator	**3**
Q5	Quantum Mechanics	Quantum Harmonic Oscillator	**4**
Q6	Quantum Mechanics	Quantum Harmonic Oscillator	**4**
Q7	Quantum Mechanics	Quantum Harmonic Oscillator	**3**
Q8	Quantum Mechanics	Quantum Harmonic Oscillator	**4**
Q9	Quantum Mechanics	Quantum Harmonic Oscillator	**4**
Q10	Quantum Mechanics	Quantum Harmonic Oscillator	**2**

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