Test Your fiziks concepts!

Topic: Quantum Mechanics

(For CSIR NET-JRF, GATE, JEST and TIFR Aspirants)

Q. The normalized wave function of an electron is

$$\psi(\vec{r}) = R(r)\left[\sqrt{\frac{3}{8}}Y_1^0(\theta,\varphi)\chi_- + \sqrt{\frac{5}{8}}Y_1^1(\theta,\varphi)\chi_+\right],$$

where Y_l^m are the normalized spherical harmonics and $\chi_\pm$ denote the wavefunction for the two spin states with eigenvalues $\pm\frac{1}{2}\hbar$. The expectation value of the z component of the total angular momentum in the above state is

(a) $-\frac{3}{4}\hbar$ (b) $\frac{3}{4}\hbar$ (c) $-\frac{9}{8}\hbar$ (d) $\frac{9}{8}\hbar$

Ans.: (b)

Solution.: $\psi(r) = R(r)\left[\sqrt{\frac{3}{8}}Y_1^0(\theta,\phi)\chi_- + \sqrt{\frac{5}{8}}Y_1^1(\theta,\phi)\chi_+\right]$

Expectation value of the total z-component of the angular momentum is $\langle\hat{J}_z\rangle = \langle\hat{L}_z\rangle + \langle\hat{S}_z\rangle$

$\langle\hat{L}_z\rangle = \sum L_z P(L_z) = 0\hbar\left(\frac{3}{8}\right) + 1\hbar\left(\frac{5}{8}\right) = \frac{5\hbar}{8}$ and $\langle S_z\rangle = \sum S_z P(S_z) = -\frac{1}{2}\hbar\left(\frac{3}{8}\right) + \frac{1}{2}\hbar\left(\frac{5}{8}\right) = \frac{\hbar}{8}$

$\therefore \langle J_z\rangle = \frac{5\hbar}{8} + \frac{\hbar}{8} = \frac{3}{4}\hbar$

Thus, correct option is (b)

Note:

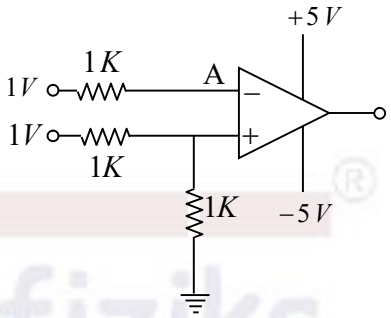
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Test Your fiziks concepts!

Topic: Electronics

(For IIT-JAM, JEST, TIFR and CUET Aspirants)

Q. In the operational amplifier circuit below, the voltage at point A is



(a) $1.0V$ (b) $0.5V$ (c) $0V$ (d) $-5.0V$

Ans.: (b)

Solution.: $V_A = \frac{1}{1+1} \times 1 = 0.5V.$

Note:

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Test Your fiziks concepts!

Topic: Modern Physics

(For PGT: KVS, NVS, DSSSB, State Education Boards, etc.)

Q. An α particle with energy of 3MeV is moving towards a nucleus of ^{50}Sn. Its minimum distance of approach to the nucleus is $f\times10^{-14}$ m. The value of f is

(a) 2.8 (b) 3.8 (c) 4.8 (d) 5.8

Ans.: (c)

Solution.:

$$K_\alpha = \frac{1}{4\pi\in_0}\frac{(+2e)(+Ze)}{x_0} \Rightarrow 3\,\cancel{MeV} = (1.44\,\cancel{MeV}.fm)\times\frac{2\times50}{x_0}$$

$$x_0 = \frac{144}{3}fm = \frac{144}{3}\times10^{-15}\text{m} = \frac{14.4}{3}\times10^{-14}\text{m} \Rightarrow x_0 = 4.8\times10^{-14}\text{m} = f\times10^{-14}\text{m} \Rightarrow f = 4.8$$

Note:

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Test Your fiziks concepts!

Topic: Quantum Mechanics

(For CSIR NET-JRF, GATE, JEST and TIFR Aspirants)

Q. 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

(a) $2\hbar$ (b) $\hbar$ (c) $-2\hbar$ (d) $-\hbar$

Ans.: (b)

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

To get m_ℓ value, compare ψ with $e^{im_\ell\phi}$. Thus, we get $m_\ell = 1$

Therefore, $\langle \hat{L}_z \rangle = m_\ell\hbar = \hbar$

Correct option is (b).

Note:

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Test Your fiziks concepts!

Topic: Electronics

(For IIT-JAM, JEST, TIFR and CUET Aspirants)

Q. An amplifier with a voltage gain of 40 dB without feedback is used in an electronic circuit. A negative feedback with a fraction 1/40 is connected to the input of this amplifier. The net gain of the amplifier in the circuit is closest to

(a) 40 dB (b) 37 dB (c) 29 dB (d) 20 dB

Ans.:(c)

Solution.:

$$A_F = \frac{A}{1+AB} = \frac{100}{1+100\times \frac{1}{40}} = \frac{100}{3.5} = 28.57 \qquad \because 40\,dB = 20\log_{10} A \Rightarrow A = 100$$

Gain in $dB = 20\log_{10} A_F = 20\log_{10} 28.57 = 29\,dB$

Note:

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Topic: Modern Physics

(For PGT: KVS, NVS, DSSSB, State Education Boards, etc.)

Q. In a X-Ray tube operating at 20 kV, the ratio of the de-Broglie wavelength of the incident electrons to the shortest wavelength of the generated X-rays is:

Given: e/m ratio for an electron $=1.76\times10^{11}$ C kg^{-1} and the speed of light in vacuum is 3×10^{8} ms^{-1}

(a) 0.10 (b) 0.12 (c) 0.14 (d) 0.16

Ans.: (c)

Solution.: de-Broglie Wavelength

$$\lambda_d=\sqrt{\frac{150}{V}}(A^\circ)=\sqrt{\frac{150}{20\times10^3}}=0.0866\times10^{-10}\text{ m}\Rightarrow\lambda_d=8.66\times10^{-12}\text{ m}$$

Shortest wavelength of X-rays produced is $\lambda_P=\frac{hc}{E}=\frac{1.24\times10^{-6}\text{ eV}}{20\times10^3\text{eV}}=6.2\times10^{-11}\text{ m}$

$$\therefore\ \frac{\lambda_d}{\lambda_P}=\frac{8.66\times10^{-12}}{6.2\times10^{-11}}=0.14$$

Note:

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