Discussion 4 Physics GRE Questions

Consider a single electron atom with orbital angular momentum $L = \sqrt{2}\hbar$. Which of the following gives the possible values of a measurement of L_z, the z-component of L?

(A) 0

(B) $0, \hbar$

(C) $0, \hbar, 2\hbar$

(D) $-\hbar, 0, \hbar$

(E) $-2\hbar, -\hbar, 0, \hbar, 2\hbar$

Characteristics of the quantum harmonic oscillator include which of the following?

I. A spectrum of evenly spaced energy states
II. A potential energy function that is linear in the position coordinate
III. A ground state that is characterized by zero kinetic energy
IV. A nonzero probability of finding the oscillator outside the classical turning points

(A) I only
(B) IV only
(C) I and IV only
(D) II and III only
(E) I, II, III, and IV

Which of the following expressions is proportional to the total energy for the levels of a one-electron Bohr atom? (m is the reduced mass, Z is the number of protons in the nucleus, $-e$ is the charge on the electron, and n is the principal quantum number.)

(A) $\frac{mZe^2}{n}$

(B) $\frac{mZe^2}{n^2}$

(C) $\frac{mZ^2e^4}{n^2}$

(D) $\frac{m^2Z^2e^2}{n^2}$

(E) $\frac{m^2Z^2e^4}{n^2}$

Let $\hat{\mathbf{J}}$ be a quantum mechanical angular momentum operator. The commutator $\left[\hat{J}_x \hat{J}_y,\ \hat{J}_x\right]$ is equivalent to which of the following?

(A) 0

(B) $i\hbar \hat{J}_z$

(C) $i\hbar \hat{J}_z \hat{J}_x$

(D) $-i\hbar \hat{J}_x \hat{J}_z$

(E) $i\hbar \hat{J}_x \hat{J}_y$

A spin-$\frac{1}{2}$ particle is in a state described by the spinor

$$\chi = A\begin{pmatrix} 1+i \\ 2 \end{pmatrix},$$

where A is a normalization constant. The probability of finding the particle with spin projection $S_z = -\frac{1}{2}\hbar$ is

(A) $\frac{1}{6}$

(B) $\frac{1}{3}$

(C) $\frac{1}{2}$

(D) $\frac{2}{3}$

(E) 1

$$\sigma_x = \begin{pmatrix} 0 & 1 \\ 1 & 0 \end{pmatrix}, \quad \sigma_y = \begin{pmatrix} 0 & -i \\ i & 0 \end{pmatrix}, \quad \sigma_z = \begin{pmatrix} 1 & 0 \\ 0 & -1 \end{pmatrix}, \quad I = \begin{pmatrix} 1 & 0 \\ 0 & 1 \end{pmatrix}$$

. Consider the Pauli spin matrices σ_x, σ_y, and σ_z and the identity matrix I given above. The commutator $\left[\sigma_x,\ \sigma_y\right] \equiv \sigma_x\sigma_y - \sigma_y\sigma_x$ is equal to which of the following?

(A) I

(B) $2i\sigma_x$

(C) $2i\sigma_y$

(D) $2i\sigma_z$

(E) 0