QM1 Concept test 5.1

Choose all of the following pairs of spin states that are <u>orthogonal</u> to each other for a spin-1/2 particle.

(1) $\left|\uparrow_z\right\rangle$ and $\left|\downarrow_z\right\rangle$ (2) $\left|\uparrow_x\right\rangle$ and $\left|\uparrow_z\right\rangle$ (3) $\left|\uparrow_z\right\rangle+\left|\downarrow_z\right\rangle$ and $\left|\uparrow_z\right\rangle-\left|\downarrow_z\right\rangle$

A. 1 only B. 2 only C. 1 and 2 only D. 1 and 3 only
E. all of the above

Concept test 5.2

Choose all of the following statements that are correct about the basis vectors for the spin degree of freedom of a single electron.

(1) The basis vector must be an eigenstate of the operator $\hat{S}^2$.

(2) The basis vector must be an eigenstate of the operator $\hat{S}_z$.

(3) Different basis vectors can be chosen based upon convenience.

A. None of the above B. 1 and 2 only C. 1 and 3 only

D. 2 and 3 only E. All of the above

QM1 Concept test 5.3

Consider a spin-3/2 system. What is the dimension of the vector space associated with this system?

A. one dimension
B. two dimensions
C. three dimensions
D. four dimensions
E. infinite dimensional space with discrete basis vectors

QM1 Concept test 5.4

Consider a spin-3/2 system. Which one of the following is true about the dimensions of the matrices used to represent the spin operators $\hat{S}_x, \hat{S}_y$, and $\hat{S}_z$ if we choose a complete set of orthonormal basis sets?

A. Each of them is a 2×2 matrix.
B. Each of them is a 3×3 matrix.
C. Each of them is a 4×4 matrix.
D. The spin operators $\hat{S}_x, \hat{S}_y$, and $\hat{S}_z$ are infinite dimensional matrices.

QM1 Concept test 5.5

Suppose the initial spin state of an electron is $a\left|\uparrow\right\rangle_z + b\left|\downarrow\right\rangle_z$ where a and b are non-zero constants. Choose all of the following statements that are correct.

(1) If we measure the z-component of the spin of the electron, we can obtain $+\hbar/2$ with a probability $|a|^2$.

(2) If we measure the x-component of the spin of the electron, we can obtain $+\hbar/2$ with a probability $|a|^2$.

(3) If we measure the x-component of the spin of the electron, we can obtain $+\hbar/2$ with a probability $\frac{1}{2}|a+b|^2$.

A. 1 only B. 2 only C. 3 only D. 1 and 2 only E. 1 and 3 only

Concept test 5.6

Choose all of the following statements that are true about the Hamiltonian $\hat{H}_0 = C(\hat{S}^2 - \hat{S}_z^2)$ for a spin-1/2 system where C is a constant.

(1) If we choose $|\uparrow_z\rangle$ and $|\downarrow_z\rangle$ as the basis vectors for the spin space, the Hamiltonian is a diagonal matrix.

(2) If we choose $|\uparrow_x\rangle$ and $|\downarrow_x\rangle$ as the basis vectors for the spin space, the Hamiltonian is a diagonal matrix.

(3) The Hamiltonian must always be diagonal by definition.

A. 1 only B. 2 only C. 1 and 2 only D. all of the above

E. none of the above