Physics 402 Quiz 1, Feb 5, 2020

Name/Student Number:

1) Which of the states below is physically equivalent to the (unnormalized) state $i|\uparrow\rangle - 2|\downarrow\rangle$?

a) $i|\uparrow\rangle + 2|\downarrow\rangle$

b) $\frac{1}{3}|\uparrow\rangle - \frac{2}{3}i|\downarrow\rangle$

c) $\frac{1}{\sqrt{5}}|\uparrow\rangle + \frac{2i}{\sqrt{5}}|\downarrow\rangle$

d) $-i|\uparrow\rangle - 2|\downarrow\rangle$

e) none of the above

2) For a quantum system with a two-dimensional Hilbert space, observables Z and X are represented by $Z = \begin{pmatrix} 1 & 0 \\ 0 & -1 \end{pmatrix}$ and $X = \begin{pmatrix} 0 & 1 \\ 1 & 0 \end{pmatrix}$ in the basis of Z eigenstates. For this system, we can say that

a) There are no states with a definite value of either Z or X.

b) Certain states have a definite value for Z or X, but no states have a definite value for both Z and X.

c) Most states do not have a definite value for both Z and X but certain special states do.

d) All states have a definite value for both Z and X.

3) At time $t = 0$, the state of a quantum system with a time-independent Hamiltonian is a linear combination of energy eigenstates with different energies:

$$|\Psi(t=0)\rangle = \sqrt{\frac{1}{3}}|E_1\rangle + \sqrt{\frac{2}{3}}|E_2\rangle \ . \tag{1}$$

For this state,

a) the probability of finding E_1 in a measurement of energy doesn't change with time, and the expectation value of energy doesn't change with time.

b) the probability of finding E_1 in a measurement of energy doesn't change with time, but the expectation value of energy can change with time.

c) the probability of finding E_1 in a measurement of energy can change with time, but the expectation value of energy doesn't change with time.

d) both the probability of finding E_1 in a measurement of energy and the expectation value of energy can change with time.

4) For a quantum system with operator $\hat{\mathcal{O}}$ associated with some observable $\mathcal{O}$, we can say that $\hat{\mathcal{O}}|\Psi\rangle$ is

a) the state $|\Psi\rangle$ after a measurement of $\mathcal{O}$.

b) proportional to the change in the state $|\Psi\rangle$ under the infinitesimal physical transformation associated with $\hat{\mathcal{O}}$.

c) always just equal to the state $|\Psi\rangle$ again but multiplied by a phase.

d) the expectation value of $\mathcal{O}$ in the state $|\Psi\rangle$.

5) If $[\hat{\mathcal{O}}, H] = 0$ for an operator $\hat{\mathcal{O}}$ in a system with time-independent Hamiltonian H, which of the following is **not** necessarily true?

a) Every energy eigenstate has a definite value for the observable $\mathcal{O}$ associated with $\hat{\mathcal{O}}$.

b) There is a basis of states for which both $\mathcal{O}$ and H are represented by diagonal matrices.

c) For any state, the probabilities for various measurement outcomes of $\mathcal{O}$ do not change with time.

d) The operator $e^{ia\hat{\mathcal{O}}}$ is a unitary matrix representing a physical transformation that is a symmetry of the system.

6) Physical transformations such as rotations are represented by unitary operators acting on the Hilbert space of a quantum system. Which of the following is **not** a property of unitary operators?

a) They are linear maps from the Hilbert space to itself.

b) They preserve the inner product between states: if $|A'\rangle = U|A\rangle$ and $|B'\rangle = U|B\rangle$, then $\langle A'|B'\rangle = \langle A|B\rangle$.

c) They have an orthogonal basis of eigenvectors with real eigenvalues.

d) They map normalized states to normalized states.

Answers

1	2	3	4	5