

Quiz Assignment 3

Note: All multi-qubit state representations are big endian, unless specified otherwise

Multi-Qubit States and Operations, Quantum Entanglement

1. Consider the following bases:
 - a. $\{|0\rangle|0\rangle, |1\rangle|1\rangle\}$
 - b. $\{|+\rangle|+\rangle, |-\rangle|-\rangle\}$
 - A. a. and b. both are orthonormal bases.
 - B. a. is an orthonormal basis, but b. is not.
 - C. a. is not an orthonormal basis, but b. is an orthonormal basis.
 - D. Neither a. nor b. is an orthonormal basis.
2. Consider the following bases:
 - a. $\{|0\rangle|+\rangle, |1\rangle|-\rangle\}$
 - b. $\{|0\rangle|i\rangle, |1\rangle|-i\rangle\}$
 - A. a. and b. both are orthonormal bases.
 - B. a. is an orthonormal basis, but b. is not.
 - C. a. is not an orthonormal basis, but b. is an orthonormal basis.
 - D. Neither a. nor b. is an orthonormal basis.
3. Is the operation $(X \otimes I) \circ (I \otimes X)$ equivalent to $X \otimes X$?
 - A. True
 - B. False
4. The operation $H \otimes H$ is self-adjoint
 - A. True
 - B. False
5. A general multi-qubit state can be visualized on one or more Bloch spheres
 - A. True
 - B. False
6. How many real numbers are required to completely describe a two-qubit state?
 - A. 4
 - B. 6
 - C. 8
 - D. 5
7. If we apply the operations $CNOT_2^1 \circ (I \otimes H)$ to the $|0\rangle|0\rangle$ state, the resultant state is:
 - A. Entangled
 - B. Separable
8. In which representation would a multi-qubit state be written as $|q_0, q_1, \dots, q_{n-2}, q_{n-1}\rangle$?
 - A. Big Endian
 - B. Little Endian
9. If the Bell rotation $CNOT \circ (H \otimes I)$ is applied to the initial state $|B_{00}\rangle$, the resultant state is:
 - A. Entangled
 - B. Separable
10. If the Bell rotation $CNOT \circ (H \otimes I)$ is applied to the initial state $|0\rangle|+\rangle$, the resultant state is:
 - A. Entangled
 - B. Separable

11. The quantum states $\frac{1}{\sqrt{2}}(|0\rangle|0\rangle + |1\rangle|1\rangle)$ and $\frac{1}{\sqrt{2}}(|+\rangle|+\rangle + |-\rangle|-\rangle)$ refer to the same quantum state.

- A. True
B. False

12. The quantum states $\frac{1}{\sqrt{2}}(|0\rangle|0\rangle - |1\rangle|1\rangle)$ and $\frac{1}{\sqrt{2}}(|i\rangle|i\rangle + |-i\rangle|-i\rangle)$ refer to the same quantum state.

- A. True
B. False

13. The quantum state $\frac{1}{\sqrt{2}}(|0\rangle|+\rangle + |1\rangle|-\rangle)$ is not entangled.

- A. True
B. False

14. The representation of the state $|0\rangle|0\rangle$ in terms of Bell basis is

- A. $|00\rangle = \frac{1}{\sqrt{2}}(|B_{00}\rangle - |B_{10}\rangle)$
B. $|00\rangle = \frac{1}{\sqrt{2}}(|B_{10}\rangle + |B_{11}\rangle)$
C. $|00\rangle = \frac{1}{\sqrt{2}}(|B_{00}\rangle + |B_{10}\rangle)$
D. $|00\rangle = \frac{1}{\sqrt{2}}(|B_{10}\rangle - |B_{11}\rangle)$

15. Consider a two-qubit system with Qubit "1" being in the state $|\psi\rangle_1 = |+\rangle$ and Qubit "2" is in the state $|\phi\rangle_2 = |-\rangle$. The vector form of the state $|\psi\rangle|\phi\rangle$ is:

- A. $\frac{1}{2} \begin{pmatrix} +1 \\ -1 \\ +1 \\ -1 \end{pmatrix}$ B. $\frac{1}{2} \begin{pmatrix} +1 \\ +1 \\ -1 \\ -1 \end{pmatrix}$ C. $\frac{1}{2} \begin{pmatrix} +i \\ -1 \\ +i \\ -1 \end{pmatrix}$ D. $\frac{1}{2} \begin{pmatrix} +1 \\ -i \\ +1 \\ -1 \end{pmatrix}$

16. The matrix form of the operator $X \otimes H$ is:

- A. $\frac{1}{\sqrt{2}} \begin{pmatrix} 0 & 0 & 1 & 1 \\ 0 & 0 & 1 & -1 \\ 1 & 1 & 0 & 0 \\ 1 & -1 & 0 & 0 \end{pmatrix}$ B. $\frac{1}{\sqrt{2}} \begin{pmatrix} 0 & 1 & 0 & 1 \\ 1 & 0 & 1 & 0 \\ 0 & 1 & 0 & -1 \\ 1 & 0 & -1 & 0 \end{pmatrix}$ C. $\frac{1}{\sqrt{2}} \begin{pmatrix} 0 & 0 & -1 & -1 \\ 0 & 0 & -1 & 1 \\ 1 & 1 & 0 & 0 \\ 1 & -1 & 0 & 0 \end{pmatrix}$ D. $\frac{1}{\sqrt{2}} \begin{pmatrix} 0 & -1 & 0 & 1 \\ -1 & 0 & 1 & 0 \\ 0 & 1 & 0 & -1 \\ 1 & 0 & -1 & 0 \end{pmatrix}$

17. In a system of two qubits, Y gate is applied to the second qubit and the X gate is applied to the first qubit. The action of this operation on basis element $|00\rangle$ and the resultant state when this operation is applied to the initial state $|01\rangle$ are respectively

- A. $i|11\rangle$ and $|10\rangle$
B. $i|10\rangle$ and $|11\rangle$
C. $-|11\rangle$ and $|10\rangle$
D. $i|11\rangle$ and $-i|10\rangle$

18. The matrix form of the operator $Z \otimes Y$ is:

- A. $\begin{pmatrix} 0 & -i & 0 & 0 \\ i & 0 & 0 & 0 \\ 0 & 0 & 0 & i \\ 0 & 0 & -i & 0 \end{pmatrix}$ B. $\begin{pmatrix} 0 & i & 0 & 0 \\ -i & 0 & 0 & 0 \\ 0 & 0 & 0 & i \\ 0 & 0 & -i & 0 \end{pmatrix}$ C. $\begin{pmatrix} 0 & -i & 0 & 0 \\ i & 0 & 0 & 0 \\ 0 & 0 & 0 & 1 \\ 0 & 0 & -1 & 0 \end{pmatrix}$ D. $\begin{pmatrix} 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & -1 \\ 1 & 0 & 0 & 0 \\ 0 & -1 & 0 & 0 \end{pmatrix}$

19. The action of the transformation $(H \otimes X) \circ CNOT$ on the basis element $|11\rangle$ is:

- A. $\frac{|01\rangle - |11\rangle}{\sqrt{2}}$ B. $\frac{|01\rangle - i|10\rangle}{\sqrt{2}}$ C. $\frac{|00\rangle + i|11\rangle}{\sqrt{2}}$ D. $\frac{|01\rangle + |11\rangle}{\sqrt{2}}$

20. The state $\frac{|+\rangle|-\rangle + |-\rangle|+\rangle}{\sqrt{2}}$ is an entangled state

- A. True
B. False