Quiz Assignment 3

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

Multi-Qubit States and Operations

1. Consider the following sets:
   a. $\{ |0,0\rangle, |1,1\rangle\}$
   b. $\{ |+,+\rangle, |-,-\rangle\}$
      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 sets:
   a. $\{ |0,+\rangle, |1,-\rangle\}$
   b. $\{ |0,i\rangle, |1,-i\}$
      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 $|00\rangle$ state, the resultant state is
      A. Entangled
      B. Separable
8. In which representation would a multi-qubit state be written as $|q_0, q_1, \cdots, q_{n-2}, q_{n-1}\rangle$?
      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

Entangled States

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 $\frac{1}{\sqrt{2}}(|\mathbf{i}\rangle|\mathbf{i}\rangle + |-\mathbf{i}\rangle|-\mathbf{i}\rangle)$ 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 $|00\rangle$ 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. $\frac{1}{2}\begin{pmatrix}+1\\-i\\+1\\-i\end{pmatrix}$
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 <u>action</u> of this operation on basis element $|00\rangle$ and the <u>resultant state</u> 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