Quiz - 7

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Graded Quiz • 1h 30m

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1. [Answer O, X] 1 point

10. An n-qubit entangled state can be characterized by $O(2^n)$ real parameters.

- (o) O
- ( ) X

2. A measurement in the basis $|\pm\rangle$ is equivalent to a measurement in the computation basis $\{|0\rangle, |1\rangle\}$ after applying a ( ) gate. 1 point

- ( ) (a) X
- (o) (b) Hadamard
- ( ) (c) SWAP

3. For a state $|+\rangle = (|0\rangle + |1\rangle)/\sqrt{2}$, suppose that a phase operation $P(\phi) = |0\rangle\langle 0| + e^{i\phi}|1\rangle\langle 1|$ is applied. When a measurement is performed in the basis $|\pm\rangle = (|0\rangle \pm |1\rangle)/\sqrt{2}$, find the angle ϕ such that the probability of obtaining out $-$ is zero. 1 point

- (o) (a) $\phi = 0$
- ( ) (b) $\phi = \pi/2$
- ( ) (c) $\phi = \pi$

4. Let U denote a quantum circuit of the Deutsch algorithm with a balanced function. How many maximally entangled states $|\phi^-\rangle$ can be generated by the circuit U? 1 point

- ( ) (a) 0
- ( ) (b) $1/2$
- (o) (c) 1

5. Suppose that two parties Alice and Bob share an entangled state 1 point

$$\rho_F = F|\phi^+\rangle\langle\phi^+| + \frac{1-F}{3}(I\otimes I - |\phi^+\rangle\langle\phi^+|).$$

Alice wants to teleport a state $|\psi(\theta,\phi)\rangle = \cos\theta|0\rangle + e^{i\phi}\sin\theta|1\rangle$ by using the shared state, and let $\rho(\theta,\phi)$ denote the resulting state. Compute the following

\begin{equation}
\int \sin\theta d\theta d\phi~ \langle \psi(\theta,\phi) | \rho(\theta,\phi) |\psi(\theta,\phi) \rangle
\end{equation}

- ( ) (a) 1
- (o) (b) F
- ( ) (c) $1/3 + 2F/3$

6. Consider a bipartite state shared by two parties in the following, 1 point

$$|\psi\rangle = \cos\theta|00\rangle + \sin\theta|11\rangle, \sim\theta \in [0, \pi/4].$$

Suppose that two parties apply LOCC on a single-copy level to distill a maximally entangled state. Find the optimal rate of the conversion.

- ( ) (a) 0
- ( ) (b) $2\sin^2\theta$
- (o) (c) $1 - 2\sin^2\theta$

7. The Choi-Jamiolkowski isomorphism establishes a one-to-one correspondence between quantum states and quantum channels. Find the quantum state corresponding to an identity channel according to the isomorphism. 1 point

- ( ) (a) $I\otimes I/2$
- ( ) (b) $|00\rangle$
- (o) (c) $|\phi^-\rangle = (|00\rangle + |11\rangle)/\sqrt{2}$

8. Consider a bipartite state $|\psi\rangle_{AB}$ that has $S(\rho_A) = 1/2$ where $\rho_A = \mathrm{tr}_B|\psi\rangle\langle\psi|$. How many maximally entangled states can be extracted by LOCC from copies of the state $|\psi\rangle_{AB}$ in the asymptotic limit? 1 point

- (a) 0
- (b) $1/2$
- (c) $1/4$

9. For a function $f : \{0,1\} \mapsto \{0,1\}$, suppose that the function is given by $f_s(x) = s \cdot x$. Consider a function evaluation $U_f|x\rangle|y\rangle = |x\rangle|y + f_s(x)\rangle$. Find the resulting qubit state in the first register in the following quantum circuit, 1 point

$$(H \otimes I)U_f|+\rangle|-\rangle$$

- (a) $|0\rangle$
- (b) $|s\rangle$
- (c) $|s+1\rangle$

10. Find the success probability of discriminating between two Pauli matrices X and Z. 1 point

- (a) $1/2$
- (b) $1/2 + \sqrt{1/8}$
- (c) 1

11. Which of the following states is more entangled? 1 point

\begin{equation}
|\psi\rangle = \sqrt{\frac{1}{3}} |00\rangle +\sqrt{\frac{2}{3}} |11\rangle,~~\mathrm{and}~~|\phi\rangle = \sqrt{\frac{1}{4}} |00\rangle +\sqrt{\frac{3}{4}} |11\rangle
\end{equation}

- (a) $|\psi\rangle$
- (b) $|\phi\rangle$
- (c) Equally entangled

12. Computing the following, 1 point

\begin{equation}
\rho = \frac{1}{6} \sum_{k = 0,1,+,-, +i,-i} |k \rangle \langle k |^{\otimes 2}
\end{equation}

- (a) $(|00\rangle\langle 00| + |01\rangle\langle 01| + |10\rangle\langle 10| + |11\rangle\langle 11|)/4$
- (b) $(|\phi^+\rangle\langle\phi^+| + |\phi^-\rangle\langle\phi^-| + |\psi^+\rangle\langle\psi^+|)/3$
- (c) $(|00\rangle\langle 00| + |11\rangle\langle 11|)/2$

** *Extra question:* **

There is a quantum algorithm which is more efficient than its classical counterpart.

Ans: O

An nn-qubit product state can be characterized by O(n)$O(n)$ real parameters.

Ans: O

Schmidt coefficients of bipartite pure states depend on the choice of local bases.

Ans: X