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BTECH
(SEM VII) THEORY EXAMINATION 2024-25
QUANTUM COMPUTING

TIME: 3 HRS

M.MARKS: 100

Note: Attempt all Sections. In case of any missing data; choose suitably.

SECTION A

1. Attempt all questions in brief. 2 x 10 = 20

| Q no. | Question | CO | Level |
|-------|---|----|------------------------------------|
| a. | Discuss the evolution of quantum information as a field. | 1 | K ₁ , K ₂ |
| b. | Elaborate on the probability amplitudes impact on measurement outcomes. | 1 | K ₁ , K ₂ |
| c. | Explore the application of quantum algorithms in solving NP-complete problems. | 2 | K ₂ , K ₃ |
| d. | Analyze the effect of decoherence on quantum search algorithms. | 2 | K ₂ , K ₃ |
| e. | How photons are manipulated within optical cavities for computation? | 3 | K ₂ , K ₃ |
| f. | Discuss the principles of NMR-based quantum computing. | 3 | K ₂ , K ₃ |
| g. | Discuss the sources of quantum noise. | 4 | K ₃ , K ₄ |
| h. | Discuss impact of Quantum decoherence on quantum computation and communication protocols. | 4 | K ₃ , K ₄ |
| i. | Discuss implementation of fault tolerance in quantum circuits. | 5 | K ₃ , K ₆ |
| j. | Discuss the challenges of implementing quantum error correction in noisy intermediate-scale quantum (NISQ) devices. | 5 | K ₃ , K ₆ |

SECTION B

2. Attempt any three of the following: 10 x 3 = 20

| Q no. | Question | C O | Level |
|-------|--|--------|------------------------------------|
| a. | Explain the principles of quantum superposition and entanglement. Discuss how these principles are utilized in quantum computation to solve problems that are intractable for classical computers. | 1 | K ₁ , K ₂ |
| b. | Develop a detailed quantum circuit for implementing the Deutsch-Jozsa algorithm. Explain the function of each gate and describe how the algorithm demonstrates quantum parallelism. | 2 | K ₂ , K ₃ |
| c. | Explain the ion-trap quantum computer architecture in detail. How does it achieve qubit initialization, manipulation, and measurement? | 3 | K ₂ , K ₃ |
| d. | Explain the concept of quantum operations and derive the Kraus operator formalism. Provide examples of how these operators model quantum noise. | 4 | K ₃ , K ₄ |
| e. | Derive mathematical expression for Shannon entropy and discuss its role in classical and quantum data compression. | 5 | K ₃ , K ₆ |

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SECTION C

3. Attempt any one part of the following: 10 x 1 = 10

| Q no. | Question | C O | Level |
|-------|---|--------|------------------------------------|
| a. | Quantum mechanics postulates form the foundation of quantum computation. Discuss these postulates, emphasizing their implications for measurement, evolution, and entanglement. | 1 | K ₁ , K ₂ |
| b. | How do quantum algorithms exploit the principles of interference and superposition to achieve exponential speedup in certain problems? | 1 | K ₁ , K ₂ |

4. Attempt any one part of the following: 10 x 1 = 10

| Q no. | Question | C O | Level |
|-------|--|--------|------------------------------------|
| a. | Analyze the Grover algorithm's steps and derive the optimal number of iterations for a given database size. | 2 | K ₂ , K ₃ |
| b. | Discuss the impact of measurement on quantum computation and strategies to minimize information loss during measurement. | 2 | K ₂ , K ₃ |

5. Attempt any one part of the following: 10 x 1 = 10

| Q no. | Question | CO | Level |
|-------|---|----|------------------------------------|
| a. | Compare the scalability and practical implementation challenges of ion traps and superconducting qubits for building large-scale quantum computers. | 3 | K ₂ , K ₃ |
| b. | Explain the guiding principles for building quantum computers. Discuss how these principles influence the design of different quantum hardware architectures. | 3 | K ₂ , K ₃ |

6. Attempt any one part of the following: 10 x 1 = 10

| Q no. | Question | CO | Level |
|-------|---|----|------------------------------------|
| a. | Analyze the relationship between quantum entanglement and entropy. How does entanglement entropy provide insights into the structure of quantum states? | 4 | K ₃ , K ₄ |
| b. | Derive the mathematical formulation of the von Neumann entropy. Discuss its relevance to quantum data compression and information transmission. | 4 | K ₃ , K ₄ |

7. Attempt any one part of the following: 10 x 1 = 10

| Q no. | Question | CO | Level |
|-------|---|----|------------------------------------|
| a. | Derive encoding and decoding process of Shor code and explain how it corrects single-qubit errors. | 5 | K ₃ , K ₆ |
| b. | Analyze the relationship between entropy and fault tolerance in quantum computation. How does entropy inform error mitigation strategies? | 5 | K ₃ , K ₆ |