INTRODUCTION TO QUANTUM TECHNOLOGIES AND APPLICATIONS

Question Bank (Part A – 2 Marks, Part B – 10 Marks)

UNIT 1: INTRODUCTION TO QUANTUM THEORY AND TECHNOLOGIES

Part A – 2 Marks Questions

1. Define superposition.

2. What is entanglement?

3. What is the uncertainty principle?

4. Explain wave-particle duality in simple terms.

5. Differentiate between classical and quantum mechanics.

6. What is meant by quantum state?

7. What is measurement in quantum mechanics?

8. Give examples of quantum systems.

9. What is meant by quantization?

10. Why are energy levels discrete in quantum theory?

11. Mention two strategic benefits of quantum technologies.

12. List any two quantum technologies.

13. What is India's Quantum Mission?

14. Name two other global quantum missions.

15. What is the significance of quantum mechanics in technology?

Part B – 10 Marks Questions

1. Explain the transition from classical to quantum physics with examples.

2. Discuss the fundamental principles of quantum theory: Superposition, Entanglement, and Uncertainty.

3. Explain wave-particle duality and its experimental evidence.

4. Compare classical and quantum mechanics in terms of theory and interpretation.

5. Explain the nature of quantum measurement and the observer's role.

6. Discuss the concept of quantization and discrete energy levels.

7. Describe various quantum systems like electrons, photons, and atoms.

8. Discuss the strategic and technological significance of quantum technologies.

9. Give an overview of quantum technologies in computing, communication, and sensing.

10. Write short notes on global quantum missions: India, EU, USA, China.

UNIT 2: THEORETICAL STRUCTURE OF QUANTUM INFORMATION SYSTEMS

Part A – 2 Marks Questions

1. What is a qubit?

2. Differentiate between classical bit and quantum bit.

3. What are trapped ions?

4. What is quantum coherence?

5. Define decoherence.

6. What is a Hilbert space?

7. What is the role of operators in quantum theory?

8. Define entanglement.

9. What is non-locality?

10. What is meant by quantum information?

11. What is classical information?

12. Mention one philosophical implication of quantum theory.

13. What is the significance of randomness in quantum physics?

14. Define determinism.

15. What is the observer's role in measurement?

Part B – 10 Marks Questions

1. Explain the concept of a qubit with examples using spin and polarization.

2. Compare classical bits and quantum bits theoretically.

3. Describe the working of quantum systems such as trapped ions and superconducting circuits.

4. Explain quantum coherence and decoherence with examples.

5. Describe Hilbert spaces, quantum states, and operators in simple terms.

6. Discuss the role of entanglement and non-locality in quantum systems.

7. Compare quantum information and classical information conceptually.

8. Explain the philosophical implications of randomness and determinism in quantum theory.

9. Describe how the observer affects the outcome in quantum systems.

10. Explain why quantum information is fundamentally different from classical information.

UNIT 3: BUILDING A QUANTUM COMPUTER – THEORETICAL CHALLENGES AND REQUIREMENTS

Part A – 2 Marks Questions

1. What is a quantum computer?

2. Define decoherence.

3. What is noise in quantum systems?

4. Mention one condition required for a functional quantum system.

5. What is scalability?

6. Define stability in a quantum context.

7. Why is maintaining entanglement difficult?

8. What is error correction?

9. Name two quantum hardware platforms.

10. What are trapped ions used for?

11. What is a superconducting circuit?

12. Mention one theoretical barrier in building quantum computers.

13. What is quantum software?

14. What is the role of control in quantum systems?

15. What is fragility in quantum computing?

Part B – 10 Marks Questions

1. Explain what is required to build a quantum computer.

2. Discuss the fragility of quantum systems and factors causing decoherence.

3. Explain the key conditions for a functional quantum computer – isolation, stability, scalability.

4. Discuss the challenges in maintaining entanglement and coherence.

5. Explain the importance of quantum error correction and its necessity.

6. Compare various quantum hardware platforms – trapped ions, superconducting circuits, photonics.

7. Describe how theoretical and practical barriers affect the progress of quantum computers.

8. Discuss the vision vs reality of quantum computer development.

9. Explain the role of quantum software in managing system complexities.

10. Discuss the theoretical challenges in scaling up quantum systems.

UNIT 4: QUANTUM COMMUNICATION AND COMPUTING – THEORETICAL PERSPECTIVE

Part A – 2 Marks Questions

1. Differentiate between quantum and classical information.

2. Define quantum communication.

3. What is Quantum Key Distribution (QKD)?

4. What is the role of entanglement in communication?

5. What is a quantum internet?

6. Define quantum parallelism.

7. What are quantum gates?

8. What is decoherence?

9. What is error correction?

10. What is the importance of quantum computing?

11. Mention one advantage of quantum communication.

12. Define classical gate.

13. Define quantum gate.

14. What is meant by quantum parallelism?

15. Mention one real-world challenge in quantum computing.

Part B – 10 Marks Questions

1. Explain the difference between quantum and classical information transfer.

2. Discuss the principles of quantum communication and QKD.

3. Explain the role of entanglement in quantum communication.

4. Describe the concept of the quantum internet and its potential.

5. Discuss the basics of quantum computing and its advantages.

6. Explain quantum parallelism and how it enables faster computation.

7. Compare classical and quantum gates theoretically.

8. Explain the challenges of decoherence and error correction in quantum systems.

9. Discuss the real-world importance and future potential of quantum computing.

10. Explain the theoretical principles behind secure quantum networking.

UNIT 5: APPLICATIONS, USE CASES, AND THE QUANTUM FUTURE

Part A – 2 Marks Questions

1. Mention one application of quantum technology in healthcare.

2. What is quantum sensing?

3. Define quantum optimization.

4. Give one industrial application of quantum computing.

5. What are the main challenges in quantum adoption?

6. What are ethical issues in quantum technology?

7. Mention one use of quantum computing in material science.

8. What is quantum precision timing?

9. List two companies working on quantum technologies.

10. What is PsiQuantum known for?

11. Define quantum logistics.

12. Mention one educational opportunity in quantum science.

13. What is India's role in global quantum research?

14. What are emerging careers in quantum domain?

15. Define standardization in the context of quantum technology.

Part B – 10 Marks Questions

1. Discuss real-world applications of quantum technology in healthcare, logistics, and materials.

2. Explain the role of quantum sensing and precision timing in industries.

3. Describe case studies of IBM, Google, Microsoft, and PsiQuantum in quantum development.

4. Discuss the ethical and societal considerations in quantum technology adoption.

5. Explain challenges to adoption such as cost, skill gap, and standardization.

6. Describe the emerging career paths in quantum technologies and the skills required.

7. Discuss the global educational and research landscape in quantum science.

8. Explain India's opportunity and progress in the global quantum race.

9. Discuss the future scope of quantum computing, communication, and sensing.

10. Explain how quantum technologies can transform scientific and industrial ecosystems.