**1. Five Core Components of Blockchain Technology**

1. **Distributed Ledger Technology (DLT):**
   * A decentralized and immutable database where all transactions are recorded.
   * Every participant (node) in the network has a copy of the ledger, ensuring transparency and trust.
2. **Consensus Mechanism:**
   * A method to agree on the validity of transactions.
   * Common mechanisms include Proof of Work (PoW), Proof of Stake (PoS), and Practical Byzantine Fault Tolerance (PBFT).
3. **Cryptography:**
   * Ensures secure communication and transaction integrity.
   * Utilizes public-key cryptography and hashing algorithms (e.g., SHA-256) for data protection.
4. **Smart Contracts:**
   * Self-executing contracts with predefined rules directly embedded in the code.
   * Enable automation and eliminate intermediaries in processes.
5. **Peer-to-Peer (P2P) Network:**
   * A decentralized network where nodes communicate directly without central authority.
   * Ensures fault tolerance and security.

**2. Scaling and Interoperability Issues in Blockchain**

1. **Scaling Problems:**
   * **Low Throughput:** Limited number of transactions per second (e.g., Bitcoin handles ~7 TPS).
   * **High Latency:** Transaction confirmation takes time (e.g., Bitcoin ~10 minutes/block).
   * **Resource Intensive:** PoW-based systems consume excessive energy and computational power.
2. **Interoperability Problems:**
   * Lack of standard protocols for communication between different blockchains.
   * Challenges in transferring assets or data across networks without intermediaries.
   * Limits broader adoption due to fragmentation of blockchain ecosystems.

**3. Blockchain in E-Commerce Transactions**

1. **Secure Payments:**
   * Enables transparent and secure payment systems with minimal risk of fraud.
2. **Smart Contracts:**
   * Automates transaction processes like order verification, payment settlements, and refunds.
3. **Supply Chain Management:**
   * Ensures authenticity by tracking goods from origin to delivery.
4. **Customer Data Security:**
   * Protects sensitive data through encryption and reduces dependency on central databases.
5. **Cost Efficiency:**
   * Removes intermediaries, lowering transaction fees.

**4. Consensus Algorithms and Their Working**

1. **Proof of Work (PoW):**
   * Nodes compete to solve complex mathematical puzzles to validate transactions.
   * Energy-intensive but highly secure (used in Bitcoin).
2. **Proof of Stake (PoS):**
   * Validators are chosen based on the amount of cryptocurrency they stake.
   * Energy-efficient and faster than PoW (used in Ethereum 2.0).
3. **Delegated Proof of Stake (DPoS):**
   * Stakeholders vote for delegates to validate transactions.
   * Offers scalability and efficiency.
4. **Practical Byzantine Fault Tolerance (PBFT):**
   * Nodes agree on a consensus despite some malicious actors.
   * Ensures high fault tolerance and speed.
5. **Proof of Authority (PoA):**
   * Validators are selected based on reputation.
   * Suitable for private blockchains.

**5. CAP Theorem Applied to Distributed Systems**

1. **Consistency:**
   * Every read receives the most recent write or an error.
2. **Availability:**
   * Every request receives a response, even if not the latest data.
3. **Partition Tolerance:**
   * The system continues to operate despite network partitions.

**Application to Blockchain:**

* Blockchain sacrifices **consistency** for **availability** and **partition tolerance.**
* Transactions are confirmed eventually (eventual consistency) due to the decentralized nature.

**6. Benefits and Limitations of Blockchain**

**Benefits:**

1. **Transparency:**
   * Every transaction is recorded and visible on the distributed ledger.
2. **Security:**
   * Cryptographic techniques ensure data integrity and resistance to tampering.
3. **Decentralization:**
   * Eliminates single points of failure and central authority control.
4. **Efficiency:**
   * Reduces intermediaries and automates processes using smart contracts.
5. **Immutability:**
   * Data, once added, cannot be altered, ensuring trust.

**Limitations:**

1. **Scalability Issues:**
   * Limited throughput and high energy consumption in PoW systems.
2. **Interoperability Challenges:**
   * Lack of standardization across different blockchains.
3. **Regulatory Uncertainty:**
   * Governments are still formulating regulations for blockchain applications.
4. **Energy Consumption:**
   * PoW systems are resource-intensive.
5. **Complexity:**
   * Requires technical expertise to implement and maintain.