Multiple choice question

(There is only one correct answer)

1. Which of the following descriptions about trees is correct?
    - A. The height of a tree equals the number of leaf nodes minus one.
    - B. All trees can be defined recursively.
    - C. A tree with n nodes has at most (but not necessarily) $n-1$ edges.
    - D. The depth of the root node is always 1.

2. In the nested list implementation of a tree, a basic characteristic of the nested list is:
    - A. Each node is implemented using a pointer to its parent node.
    - B. Each node consists of an element and a list, where the list contains the node's children.
    - C. Each subtree of the tree must have the same number of child nodes.
    - D. The values of the nodes are stored in the leaf nodes.

3. The number of leaf nodes in a binary tree is _____ compared to the number of nodes with degree 2.
    - A. Unrelated
    - B. Equal
    - C. One more
    - D. One less

4. In a complete binary tree with 2024 nodes, how many leaf nodes are there?
    - A. 1011
    - B. 1012
    - C. 1013
    - D. 1014

5. In a binary tree, if there are 18 nodes with degree 2 and 10 nodes with degree 1, how many nodes have degree 0?
    - A. 46
    - B. 28
    - C. 19
    - D. 17

6. Given a binary tree's preorder traversal sequence `[A, B, D, E, C, F, G]` and inorder traversal sequence `[D, B, E, A, F, C, G]`, what is the postorder traversal sequence?
    - A. `[D, E, B, F, G, C, A]`
    - B. `[D, E, F, G, C, B, A]`
    - C. `[D, E, B, G, F, C, A]`
    - D. `[E, D, B, G, F, C, A]`

7. Given a binary tree with the level-order traversal sequence `[3, 9, 20, 15, 7]` and the inorder traversal sequence `[9, 3, 15, 20, 7]`, which of the following is the postorder traversal sequence?
    - A. `[15, 7, 20, 9, 3]`
    - B. `[9, 15, 7, 20, 3]`
    - C. `[9, 15, 20, 7, 3]`
    - D. `[15, 20, 7, 9, 3]`

8. In a binary tree, if node m is an ancestor of node n, which traversal can be used to find the path from m to n?
    - A. Level-order traversal
    - B. Preorder traversal
    - C. Inorder traversal
    - D. Postorder traversal

9. Which of the following statements about binary search trees (BSTs) is incorrect?
    - A. In a valid BST, all nodes in the left subtree have values smaller than the root node.
    - B. In a BST, the time complexity of searching for a value in the worst case can be $O(n)$.
    - C. After inserting a node into a BST, the height of the entire tree needs to be adjusted.
    - D. For a BST with n nodes, the average time complexity of a search is $O(\log n)$.

10. When performing a delete operation in a binary search tree (BST), if the node to be deleted has two children, what is the most common operation?
    - A. Replace it with the smallest node in its right subtree and recursively delete that node.
    - B. Replace it with the smallest node in its left subtree and recursively delete that node.
    - C. Replace it with the largest node in its right subtree and recursively delete that node.
    - D. Replace it with the largest node in its left subtree and recursively delete that node.

11. After inserting a new node into an AVL tree, if a node's balance factor becomes 2 and the balance factor of its left subtree is 1, which rotation operation should be performed?

- A. Single right rotation
- B. Single left rotation
- C. Left rotation followed by right rotation
- D. Right rotation followed by left rotation
- E. No rotation is required

12. For an empty AVL tree, if nodes are inserted in the order `[10, 20, 30, 40, 50, 25]`, what rotation operation is required after inserting node 25?
    - A. Single right rotation
    - B. Single left rotation
    - C. Right rotation followed by left rotation
    - D. Left rotation followed by right rotation
    - E. No rotation is required

13. Which of the following statements about AVL trees is incorrect?
    - A. An AVL tree is a binary search tree based on balance factors.
    - B. In an AVL tree, the height difference between the left and right subtrees cannot exceed 1.
    - C. Rebalancing an AVL tree may require single or double rotations.
    - D. Insert operations in AVL trees are faster than in regular BSTs because of the rebalancing process.

14. Ideally, what is the time complexity of inserting a node into a binary search tree?
    - A. $O(n^2)$
    - B. $O(n \log n)$
    - C. $O(\log n)$
    - D. $O(n)$

15. In an AVL tree, the operation of updating balance factors is most closely related to which process?
    - A. The number of rotations performed.
    - B. Changes in subtree height after inserting or deleting a node.
    - C. The number of times tree nodes are accessed.
    - D. The order of the inorder traversal.

16. Among ordered lists, hash tables, regular BSTs, and AVL trees, which of the following comparisons about their operational efficiency is correct?
    - A. The time complexity for insertion and search in hash tables is always $O(1)$.

- B. In the worst case, the search time complexity of a regular BST is $O(\log n)$.
- C. The search efficiency of an ordered list is better than that of an AVL tree.
- D. The worst-case search efficiency of an AVL tree is better than that of a regular BST.

Short Questions

1. What is a Tree? Briefly describe and compare the basic definition (Definition 1) and the recursive definition (Definition 2).

2. In an expression parse tree:

- What does each node represent? (1 sentence)
- How to distinguish operator nodes from operand nodes? List two common methods.

3. Given the expression `A + B * (C - D) - E / F`, draw the process of constructing the expression parse tree. (No code needed, only diagrams)

4. Insert the nodes `[34, 23, 15, 98, 115, 28, 107]` sequentially into an initially empty balanced binary search tree (AVL Tree). Draw the resulting tree after each insertion. (No code needed, only diagrams)

5. Given the following nested list representation of a binary tree, list the left and right subtrees of nodes `'B'` and `'C'` in list form.

```
myTree = ['A', ['B', ['D', [], []], ['E', [], []]], ['C', [], ['F', [], []]]]
```