※ 注意：請用 2B 鉛筆作答於答案卡，並先詳閱答案卡上之「畫記說明」。

多重選擇題，共20題，每題5分。
（每題五個選項，其中至少有一個是正確的答案。各題之選項獨立計分，每答對一個選項，得題分之五分之一；該題不作答者，得零分。每答錯一個選項時，倒扣題分的五分之一，每題倒扣至零分為止。）

Notes:

a) **Height of Binary Trees**
The height of an empty binary tree is defined as 0, and the height of a binary tree with only one node is defined as 1.

b) **Graphs**
A graph does not contain self-circular edges, *e.g.*, (u,u), nor multiple edges between two nodes, *i.e.*, at most one entry (u,v) in E for each distinct u and v.

1. Which of the following statement(s) is (are) true?
   A. $5\log n+\log\log n^2$ is $\Theta(\log n)$
   B. If $g_1(n)\in O(f_1(n))$ and $g_2(n)\in O(f_2(n))$ then $g_1(n)+g_2(n)\in O(\min\{f_1(n),f_2(n)\})$
   C. If $g_1(n)\in O(f_1(n))$ and $g_2(n)\in O(f_2(n))$ then $g_1(n)g_2(n)\in O(f_1(n)+f_2(n))$
   D. $f(n)\in O\left((f(n))^2\right)$
   E. If and only if $g(n)\in\Omega(f(n))$, $f(n)\in O(g(n))$

2. The following code segments show two versions of implementation of the Fibonacci number:
   a)
```
long f(long n){
  if(n ==0) return 0;
  else if(n==1) return 1;
  else return f(n-1) + f(n-2);
}
```
   b)
```
long f(long n){
  long i=2;
  long Fib[n];
  Fib[0]=0;
  Fib[1]=1;
  while(i<=n)
  {
    Fib[i] = Fib[i-1] + Fib[i-2];
  }
  return Fib[i];
}
```

Which of the following statement(s) is (are) true?
   A. $f(8)=55$.
   B. The complexity of version a) is $O(n)$.
   C. The complexity of version b) is $O(n)$.
   D. Version a) is the recursive version.
   E. Version a) is more efficient.

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3. The following table shows a series of stack operations:
(top() returns the top element of the stack without popping it out.)

Operation	Output
push(7)	--
push(5)	--
pop()	*A*
push(2)	--
push(9)	--
top()	*B*
pop()	*c*
pop()	*d*
size()	*e*
pop()	*f*
isEmtpy()	*g*

Which of the following statement(s) is (are) true?
A. The stack works according to the first-in-first-out (FIFO) principle
B. $b - c = 0$
C. $d + e = 8$
D. g = "false"
E. The required maximum size to implement this stack is 4

4. In C++, one uses the following code to allocate an array **int** x[6].
int *x;
x = **new int** [6];
The code "cout<<&(x[0])" shows 800. Based on the following memory table, which of the following statement(s) is (are) true? Each pointer and integer takes two bytes.

Address	Content
800	806
802	808
804	400
806	912
808	410
810	1024

A. The outputs of "cout<<x" and "cout<<&x" are the same.
B. The outputs of "cout<<*x" and "cout<<x" are the same.
C. The output of "cout<<x[1]" = 808.
D. The output of "cout<<&(x[2])" = 804.
E. The output of "cout<< &(x[2]+x[4])" = 1024.

5. When a queue data structure is implemented using a circular array Q[ ], the queue operations are implemented as the following code segments, where
f denotes the front of the queue. *f* is the index to the cell storing the first element of the queue;
r denotes the rear of the queue. *r* is the index to the cell storing the last element of the queue;
N denotes the size of the circular array;
% denotes the modulo operator.

Function size(){
return A;}
Function isEmpty(){

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```
    return (f==r);}
Function B(){
    if (isEmpty())
        throw a QueueEmptyException;
    return Q[f];}
Function C(){
    if (isEmpty())
        throw a QueueEmptyException;
    temp = Q[f];
    f = (f+1)%N;
    return Q[f];}
Function D(data){
    if(size()==N-1)
        throw a QueueFullException;
    Q[r]=data;
    r=(r+1)%N;}
```

Which of the following statement(s) is (are) true?

A. A should be $r - f$.
B. Function B is dequeue.
C. Function C is enqueue.
D. Function D is enqueue.
E. The largest size of the queue is N.

6. For the following statements about linked-list, which of the following statement(s) is (are) true?
   A. The operation of inserting or deleting a node of a singly-linked-list has the complexity O(1).
   B. If a singly-linked-list is used to implement a stack, it is more efficient to have the top of the stack at the tail of the list.
   C. If a singly-linked-list is used to implement a queue, it is more efficient to have the front of the queue to be at the head of the linked list, and the rear of the linked list to be at the tail of the list.
   D. Given the pointer to the node to be deleted, the node deleting operation of a doubly-linked-list has lower complexity than that of a singly-linked-list.
   E. One of the advantages of circular linked list is that it is able to traverse the list starting at any point.

7. Which of the following expression(s) is (are) equivalent to the postfix expression "AB+C–DE*F+*"?
   A. The infix expression ((A+B) –C)*(D*E+F)
   B. The prefix expression *+*DEF–+ABC
   C. The prefix expression *++ABC–*DEF
   D. The postfix expression AB+C–DE*F+*
   E. The postfix expression DE*F+AB+C–*

8. Which of the following statement(s) about binary tree is (are) true? Let T be a binary tree with n nodes, and let h denote the height of T.
   A. The number of external nodes in T is at most 2^{h-1}.
   B. The number of internal nodes in T is at most 2^{h-2}.
   C. The height of T is at least $\log_2(n+1)$.
   D. The height of T is at most $(n-1)/2$.
   E. The number of distinct T is $\dfrac{2n!}{(n+1)!n!}$

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9. Which of the following statement(s) about binary search tree (BST) is (are) true? Let T be a binary tree with n nodes, and let h denote the height of T.
   A. In a BST, every subtree is also a BST.
   B. In a binary tree, if both the left and right subtrees of the root are BSTs, this tree is a BST .
   C. The search time for an element is O(log n) in the worst case.
   D. If we want to visit the nodes in a BST in an ascended order, preorder traversal should be employed.
   E. A BST with n keys generated from a random series of insertions and removals of keys has the expected $h = O(\log n)$.

10. Consider the following sequence of operations for a empty binary search tree (BST): insert(5), insert(4), insert(2), insert(7), insert(9), insert(3), insert(6). Which of the following statement(s) is (are) true?
   A. The height of the tree is 4.
   B. The result of a postorder traversal is 3246975.
   C. The result of a inorder traversal is 2345679.
   D. After the operation of delete(5), the result of preorder traversal may be 432769.
   E. After the operation of delete(5), the result of preorder traversal may be 642379.

11. Which of the following statement(s) is (are) true?
   A. With closed addressing, the hash table's storage cells are defined as multi-record buckets, usually implemented as linked lists.
   B. With open addressing, a special algorithm is used to locate an open (empty) cell to store the colliding record. This is also called separate chaining.
   C. Rehashing is a way to overcome primary clustering, which is when records begin to accumulate in long strings of adjacent positions instead of being uniformly distributed throughout the table.
   D. Quadratic probing and double hashing reduce primary clustering.
   E. Linear probing suffers from secondary clustering, which occurs when different keys hash to the same index, but quadratic probing does not.

12. Which of the following statement(s) about "tree and graph" is (are) true?
   A. Any undirected graph without cycle is a tree.
   B. *Any undirected graph with n nodes and $(n-1)$ edges, where $n \geq 1$, is a tree.*
   C. Any undirected graph where every node connects to at least one other node is a tree.
   D. Any connected undirected graph is a tree.
   E. None of the above.

13. Which of the following statement(s) about "binary min heap" is (are) true?
   A. A binary min heap is also a binary search tree.
   B. Every subtree of a binary min heap is also a binary min heap.
   C. Initializing a binary min heap of n elements takes $\Theta(n \log n)$ time.
   D. Extracting the minimum from a binary min heap takes $\Theta(\log n)$ time.
   E. Inserting an element into a binary min heap with n elements takes $\Theta(n)$ time in the worst case.

14. Starting from empty, we insert 40, 37, 24, 5, 35, 31, and 33 (in that exact order) to an AVL tree. Which of the following statement(s) is (are) true?
   A. The root is 35.
   B. The height of the tree is 4.
   C. The result of a postorder traversal is 33 5 31 24 40 37 35.
   D. The result of a inorder traversal is 5 24 31 33 35 37 40.
   E. The left subtree is bigger than the right subtree.

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15. Define $n(h)$ as the number of nodes of an AVL tree of height h ($n(1) = 1$ by definition). Which of the following statement(s) is (are) true?
   A. $\min(n(5)) = 12$.
   B. $\max(n(5)) = 32$
   C. $\max(n(h)) = 2\times\max(n(h\text{-}1)) + 1$.
   D. $\min(n(h)) = 2\times\min(n(h\text{-}1)) + 1$.
   E. $\min(n(h)) = \Theta(h)$.

16. Which of the following statement(s) about "red-black tree" is (are) true?
   A. In a red-black tree, every red node must have two black children.
   B. In a red-black tree, every black node must have two red children.
   C. In a red-black tree, every path from the root to any external nodes contains same number of red nodes.
   D. A red-black tree with n nodes (including external) contains exactly $(n+1)/2$ external nodes.
   E. The highest ratio of the number of red internal nodes to the number of black internal nodes is 2.

17. Initially, each set contains one unique element. Which of the following statement(s) about "the union-and-find problem" is (are) true?
   A. To have a set with n elements, at least $(n\text{-}1)$ unions are required.
   B. In the worst case, finding an element in a set of size n takes $\Theta(\log n)$ time
   C. If we always make the taller tree as a subtree of the shorter during union, the height of the tree representing a set with n elements is at least $\Theta(n)$.
   D. If we always make the shorter tree as a subtree of the taller during union, the height of the tree representing a set with n elements is at most $\Theta(\log n)$.
   E. u unions and f finds can be done in $\Theta(u+f)$ time.

18. Which of the following statement(s) about "a graph with V vertices and E edges" is (are) true?
   A. The adjacency list representation takes $\Theta(V+E)$ space.
   B. The adjacency matrix representation takes $\Theta(V+E)$ space.
   C. Finding if an edge exists in the adjacency list representation takes $\Theta(1)$ time.
   D. Finding if an edge exists in the adjacency matrix representation takes $\Theta(E)$ time.
   E. The adjacency matrix representation is more suitable than the adjacency list representation for sparse matrices.

19. Suppose sparse matrices are on average of size n by n with m non-zero entries ($n<m<n^2$), and we store a sparse matrix by several lists: one list per row. Which of the following statement(s) is (are) true?
   A. One such sparse matrix takes $\Theta(n^2+m)$ space.
   B. Accessing an entry takes $\Theta(m)$ time on average.
   C. Accessing an entry takes $\Theta(nm)$ time in the worst case.
   D. Accessing all entries of a row takes $\Theta(m)$ time on average.
   E. Accessing all entries of a column takes $\Theta(m)$ time on average.

20. Consider a hash table of 19 buckets, and every of which holds only key. The hash function is $f(key) = key \% 19$, where "%" denotes the modulo operator. We use the linear probing scheme and insert 5, 9, 24, 44, 50, 10, 6 , 41, 11, 47, and 25 (in exact that order) into the hash table. Which of the following statement(s) is (are) true?
   A. 25 is stored at the 13-rd bucket.
   B. 11 is stored at the 11-st bucket.
   C. 6 is stored at the 7-th bucket.
   D. Finding 47 takes 3 look-ups.
   E. If we delete 44, 50 will be stored at the12-th bucket.

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