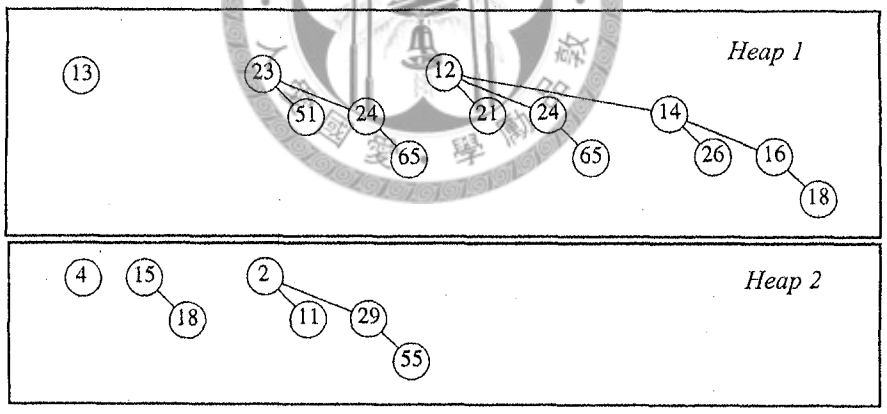
※ 注意：請於答案卷上依序作答，並應註明作答之大題及其題號。

第一題: (20 pts) True or False? (是非題; 對的寫'O'; 錯的寫'X') (NO penalty for wrong answer.)

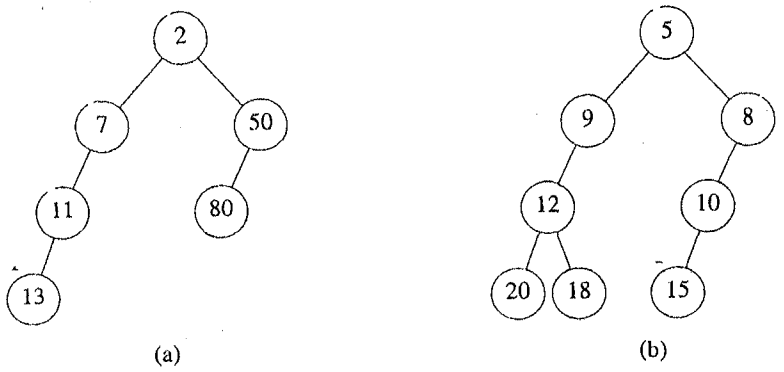
1. $log(n!) = \Theta(n \log n)$
2. A *search* in a *skip list* of *n* elements takes O(log n) time in the worst case.
3. An *insertion* to an *n*-node AVL tree may require O(log n) *rotations* in the worst case to re-balance the tree.
4. Two distinct (i.e., different) binary trees cannot have the same post-order traversal sequence.
5. *Shell-sort* is in time O(n log n) in the worst case.
6. *Arrays* and *linked lists* are two kinds of linear *abstract data types* (ADTs).
7. The height of an *n*-node *red-black tree* is always O(log n).
8. The height of a *2-3-4 tree* of *n* keys is always O(log n).
9. A *splay* operation in *splay trees* may require $\Omega(n)$ time in the worst case.
10. *Merging* two *AVL trees* of *n*-node each can be done in O(n) time in the worst case.

第二題:

1. **(10 pts)** Given a ***binomial min-heap*** of *n* keys, what is the worst-case running time of each of the following operations?
   (1) *Insertion* (2) *Delete-minimum* (3) *Find-minimum* (4) *Merge* (5) *Decrease-key*.
2. **(10 pts)** Merge (合併) the following two ***binomial min-heaps***. Show your derivation in sufficient detail.

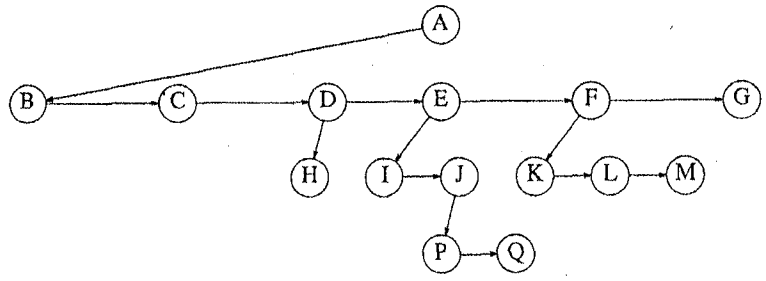


3. **(10 pts)** Merge the following two ***leftist heaps***. Show your work in sufficient detail.



接背面

第三題: (10 pts) Draw the *ordered tree* (not necessarily binary) whose *binary tree representation* is the following:



第四題:

1. **(10 pts)** Insert ***5, 1, 10, 2, 8, 4, 9, 6, 7, 3*** into an initially empty *2-3 tree*. Show your work in sufficient detail.
2. **(10 pts)** Insert ***5, 1, 2, 8, 4, 6, 7, 3, 10, 9*** into an initially empty *AVL tree*. Show your work in sufficient detail.

第五題:

(20 pts) Given a hash table of size 10 (assuming that the hash table starts with index 0), show how the following data (in the given order) would be stored in the table using *double hashing*:

$$h_1(x) = x \% 10 \quad \text{and} \quad h_2(x) = 2 + (x \% 7)$$

Data: ***99, 15, 75, 36, 20, 25, 89, 0, 47, 42***

(**Note**: $x \% y$ denotes the remainder of x divided by y. For instance, 27 %10 = 7; 27 %7 = 6)

(註: 如下表, 在答案卷上寫出 hash table 的內容 (即 '?' 內容); 推導過程不需寫出)

Index	0	1	2	3	4	5	6	7	8	9
Data	?	?	?	?	?	?	?	?	?	?