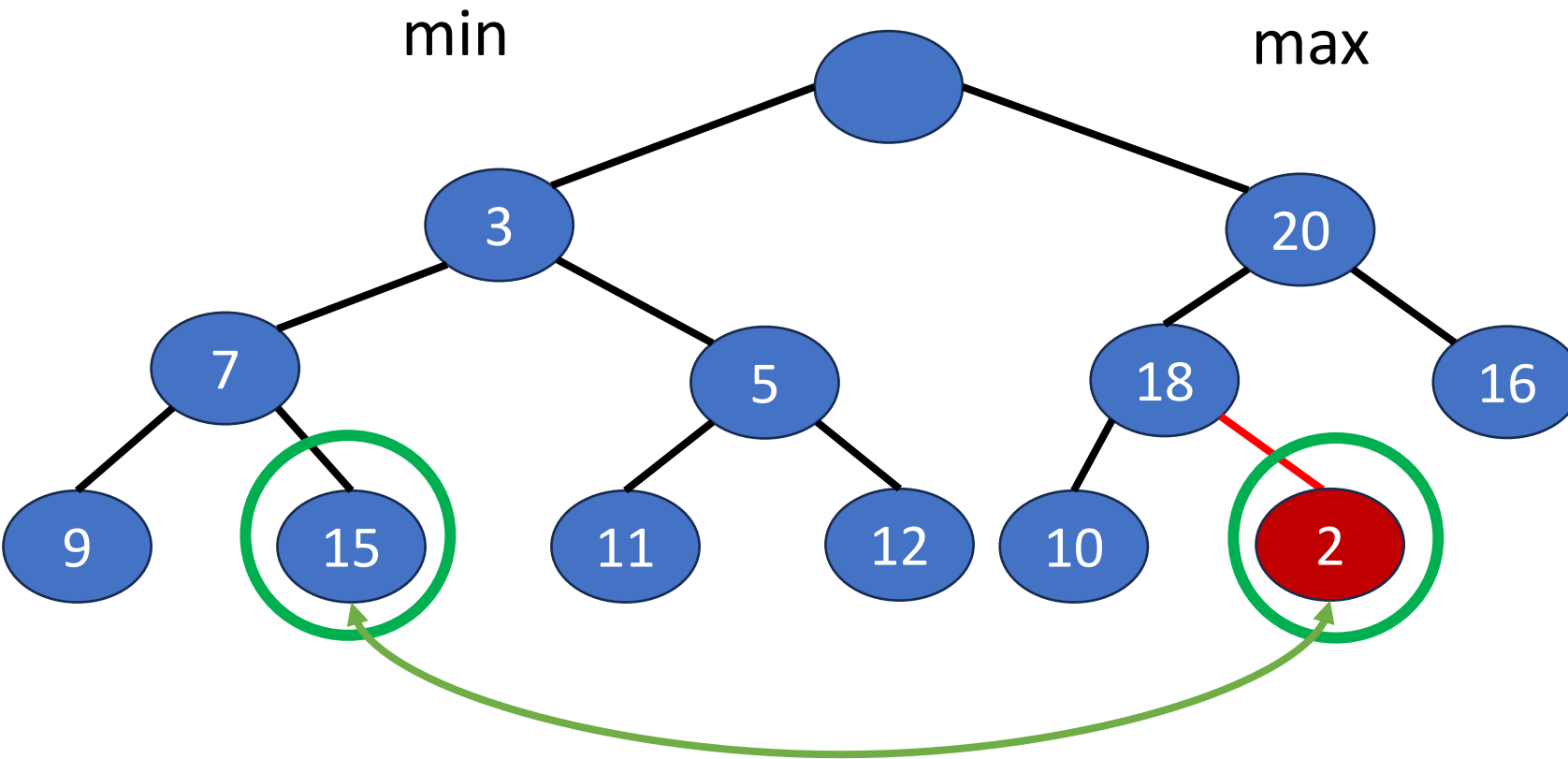
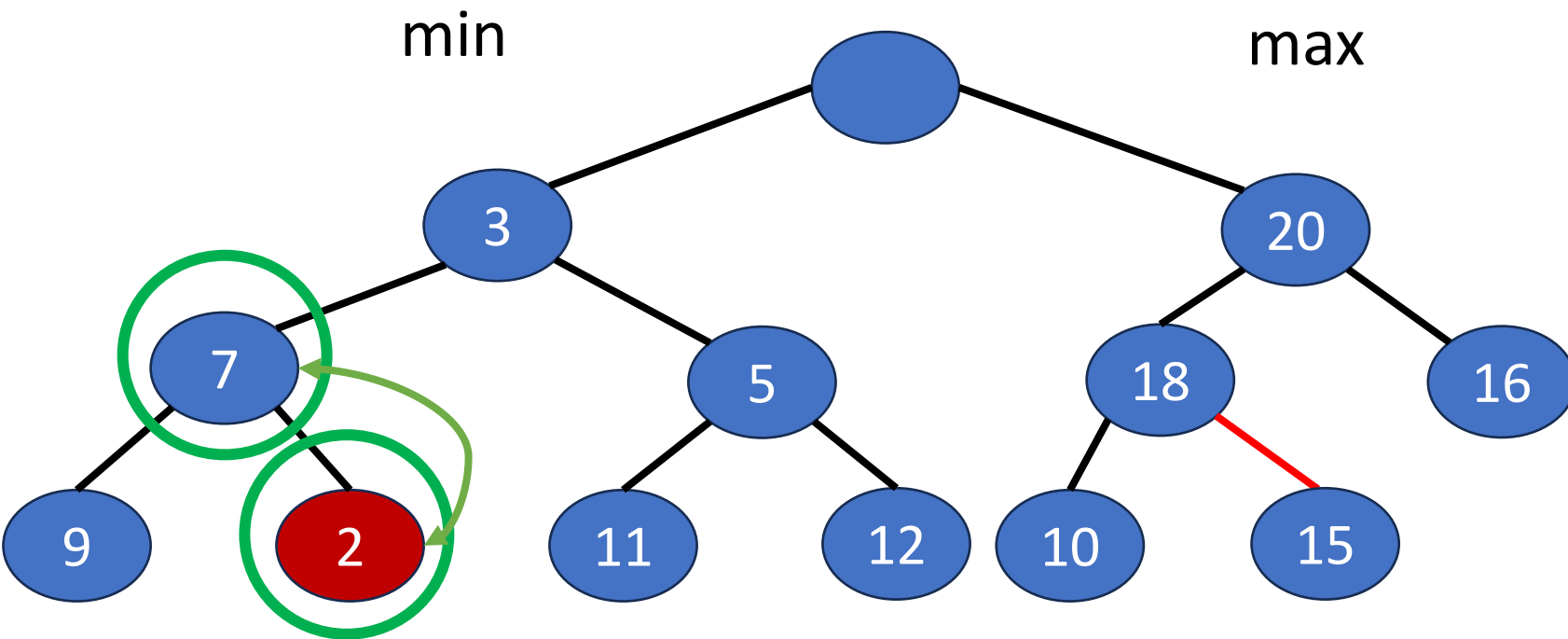


Deap

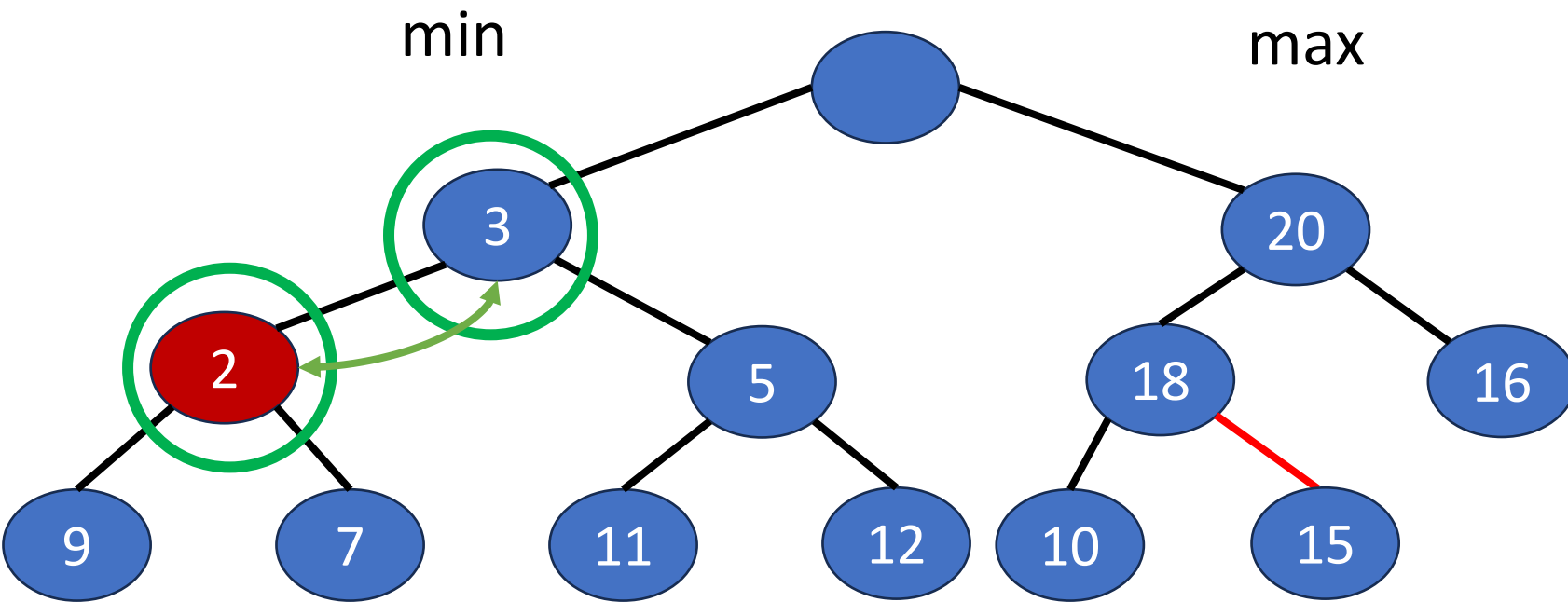
- Q1: Insert 2 into the following deap. Where will be the location of 2?



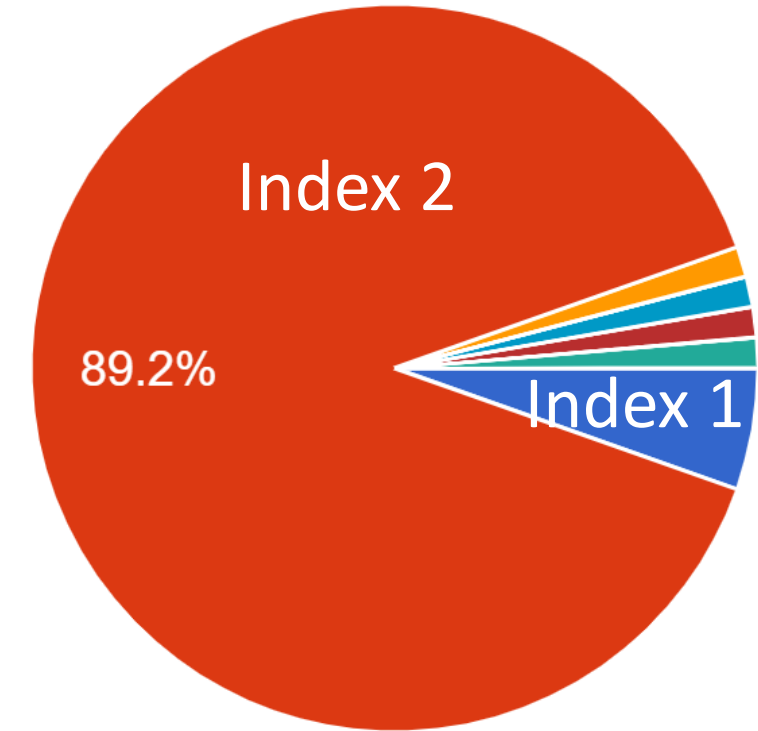
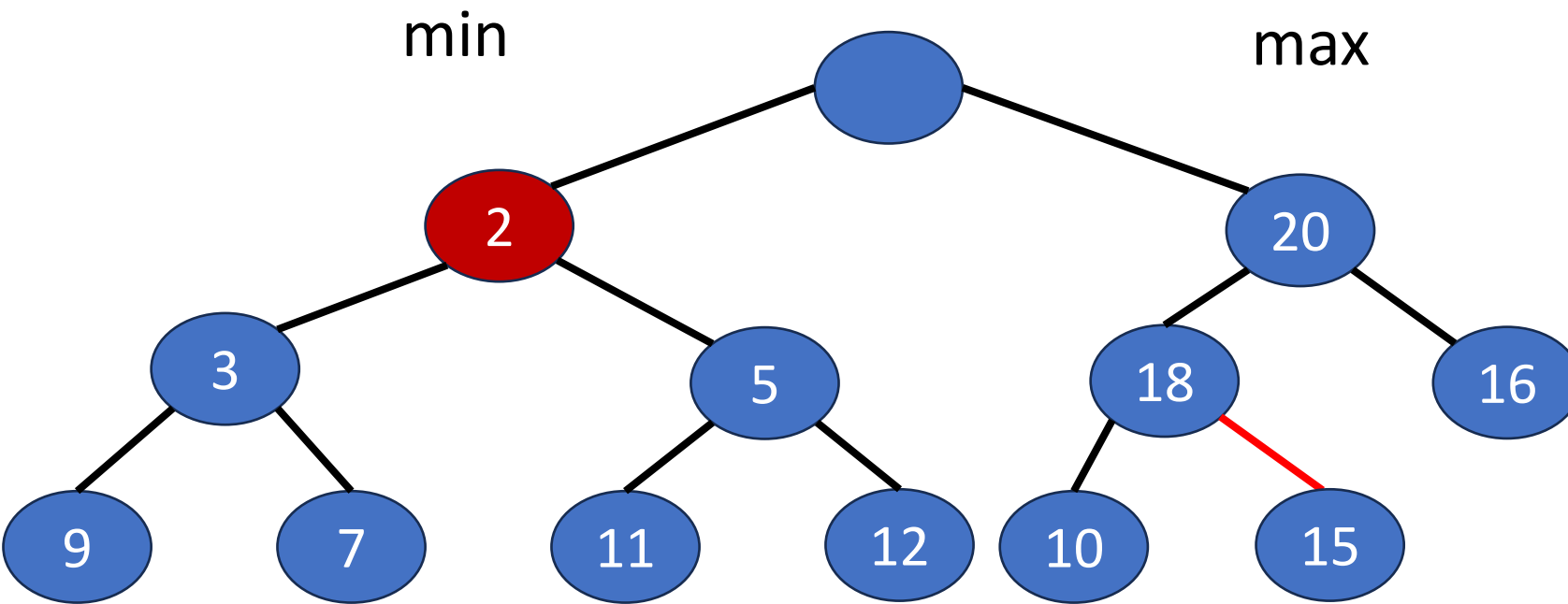
Deap



Deap



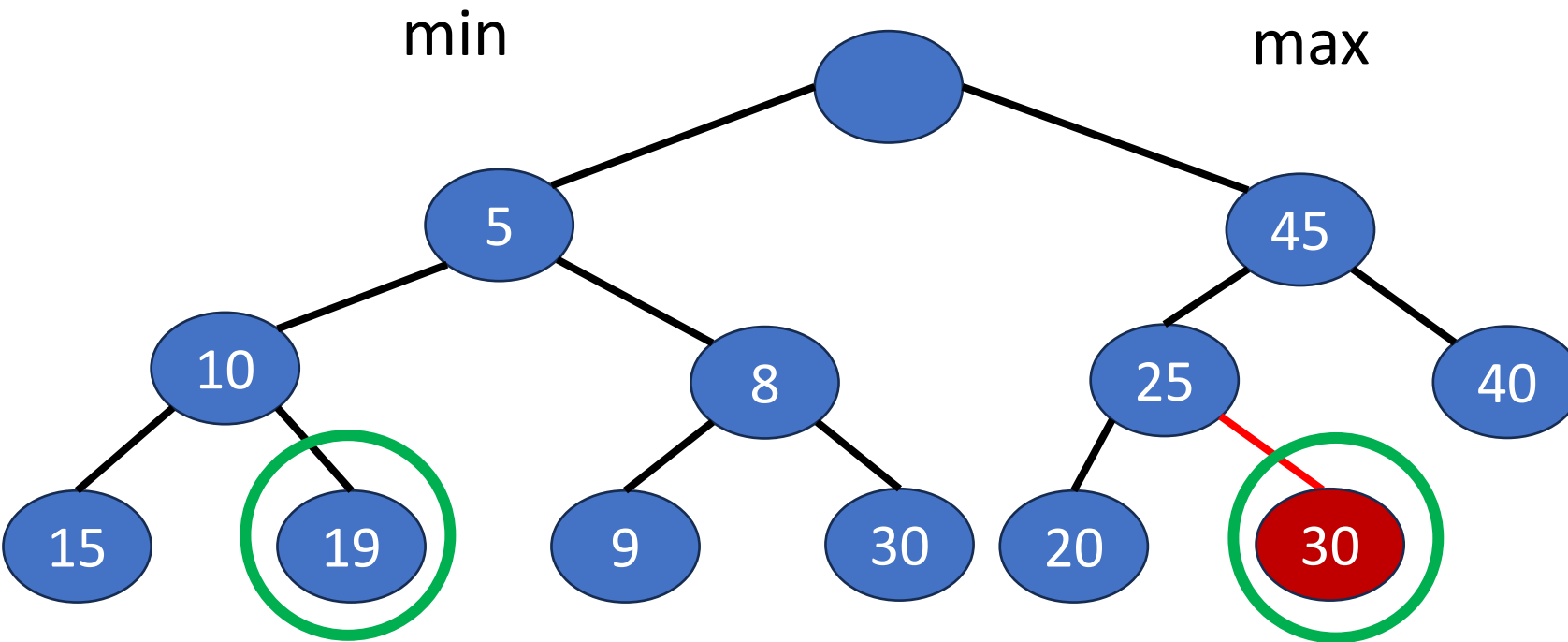
Deap



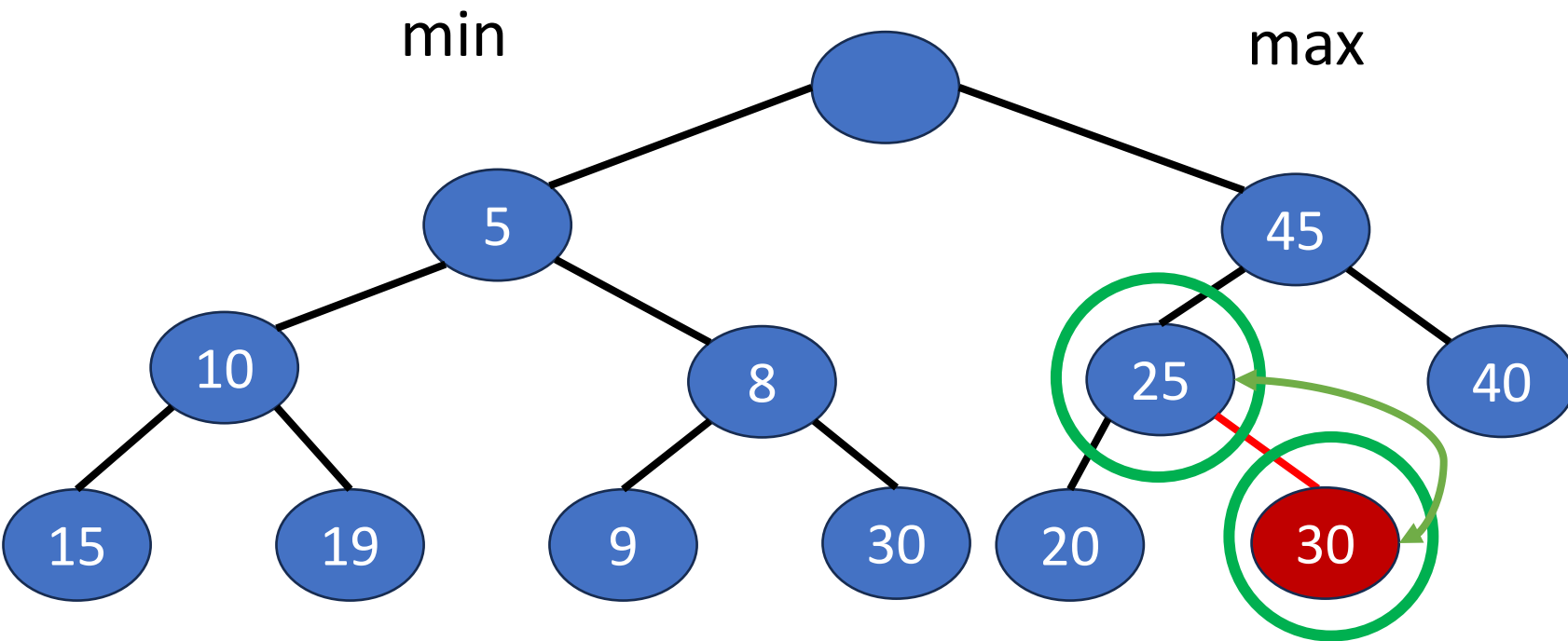
The node with key 2 is at index 2.

Deap

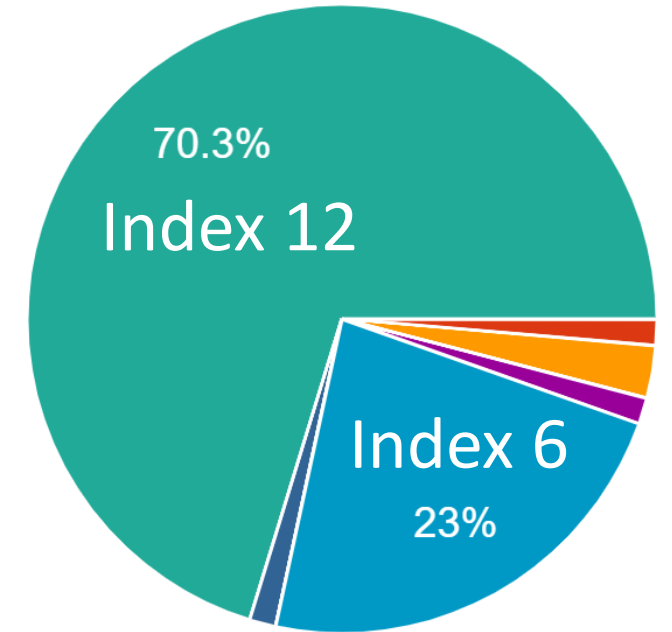
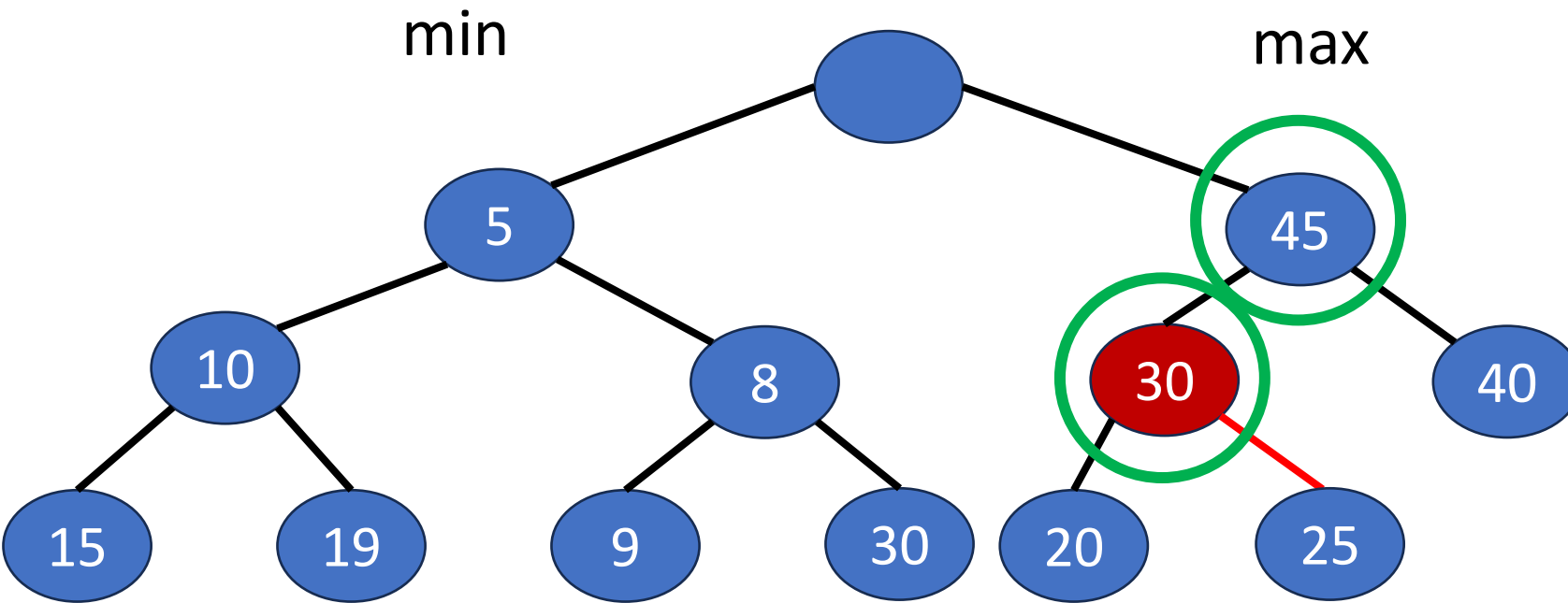
- Q2: Insert 30 into the following deap. Where will be the location of 20?



Deap



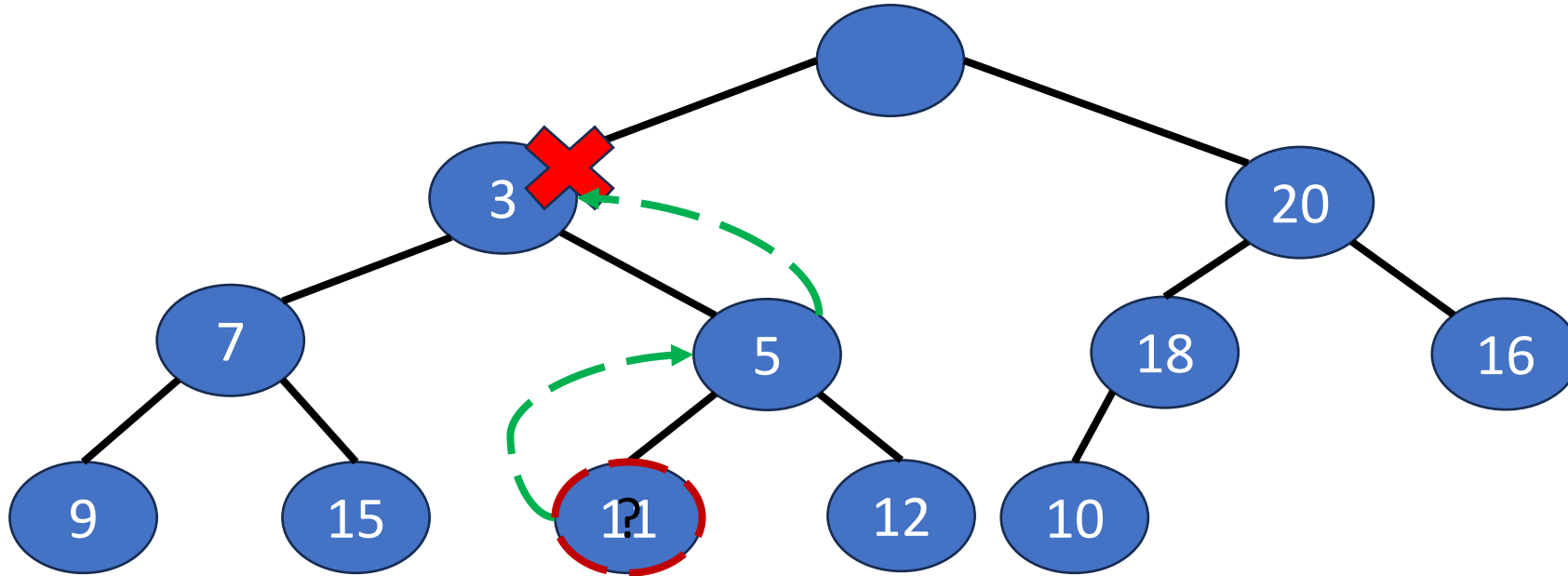
Deap



The node with key 20 is at index 12.
The **red node** with key **30** is at index 6.

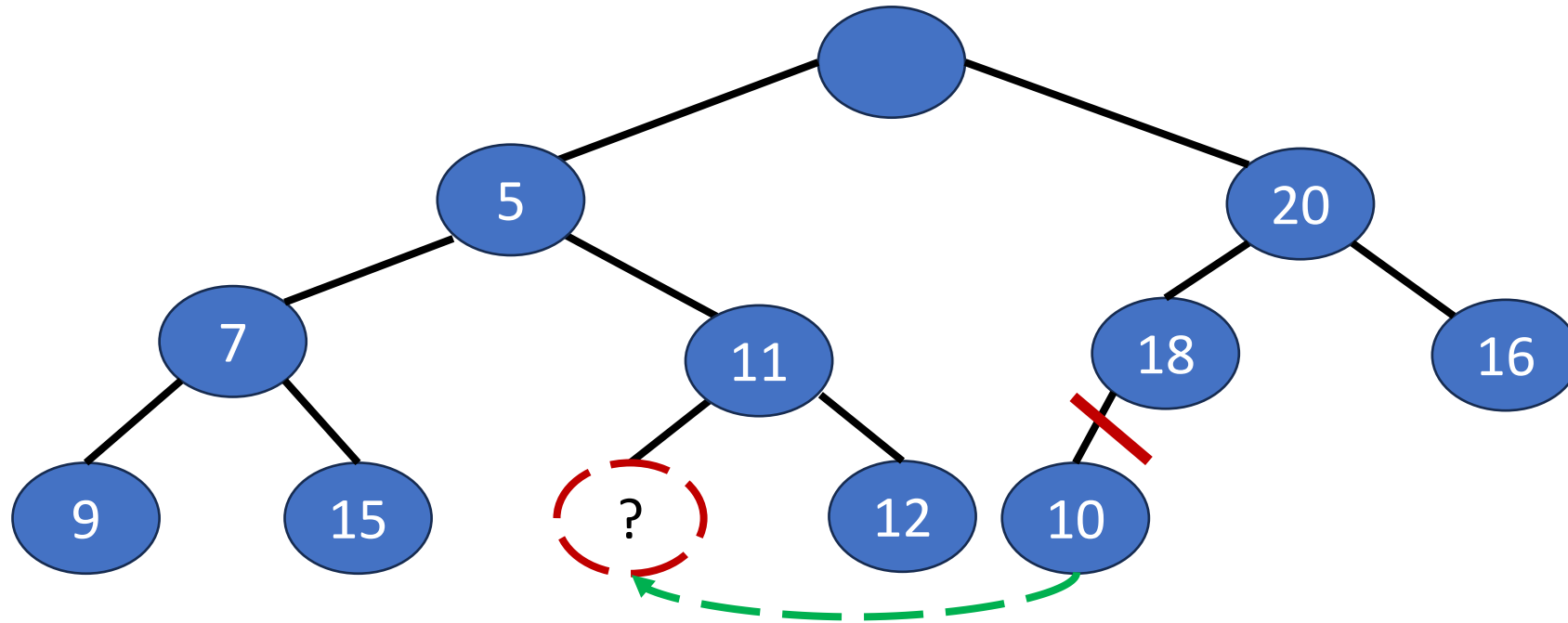
Deap

- Q3: Delete the min element from the following deap. Where will be the location of 10?



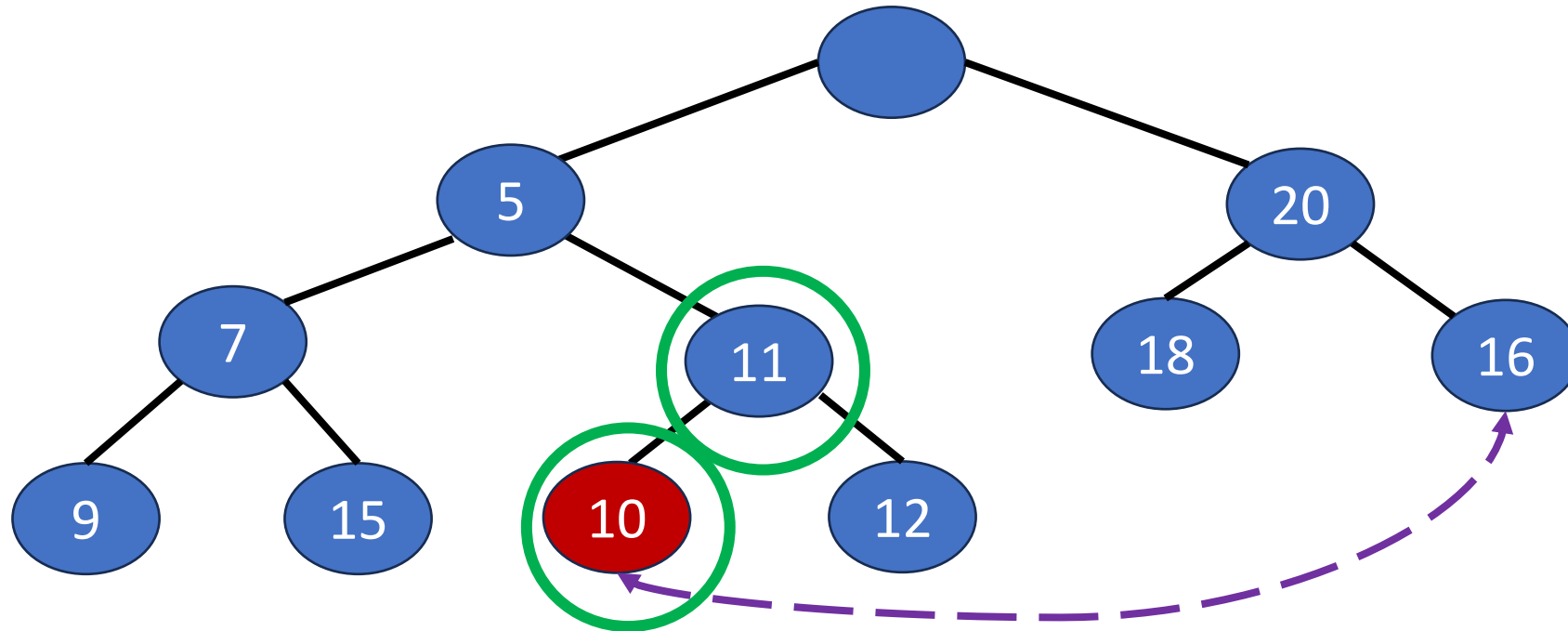
Move the child with the min key to replace the empty spot.

Deap



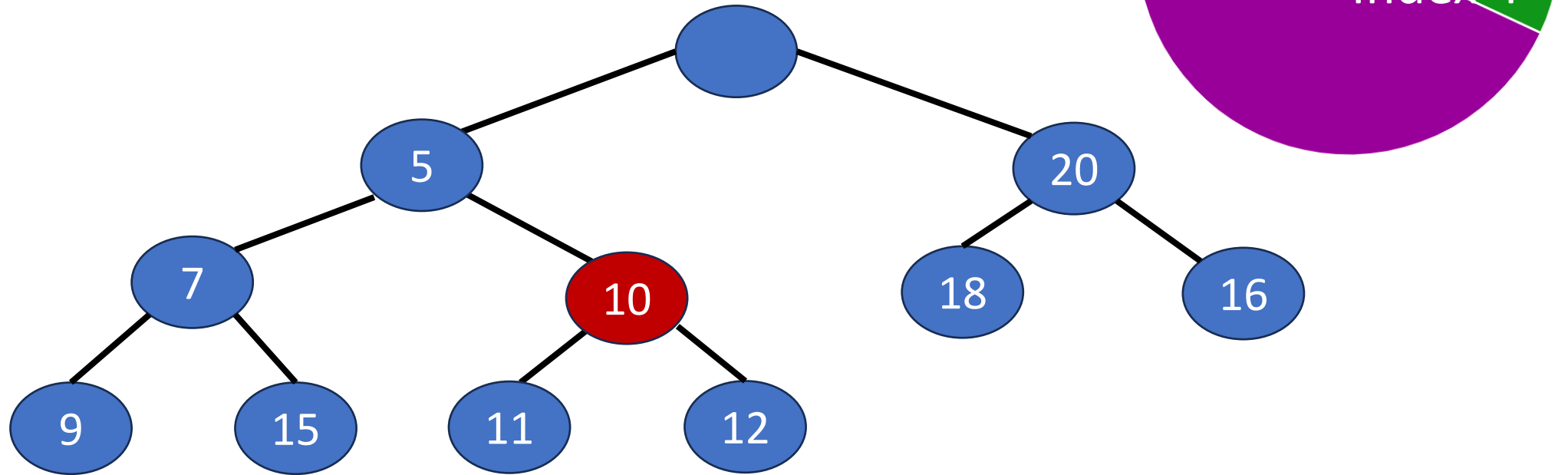
Move the last node to the empty leaf node.

Deap



1. Compare with the corresponding node: $10 < 16 \rightarrow$ don't change
2. Reorganize the location in the min heap: $10 < 11 \rightarrow$ swap

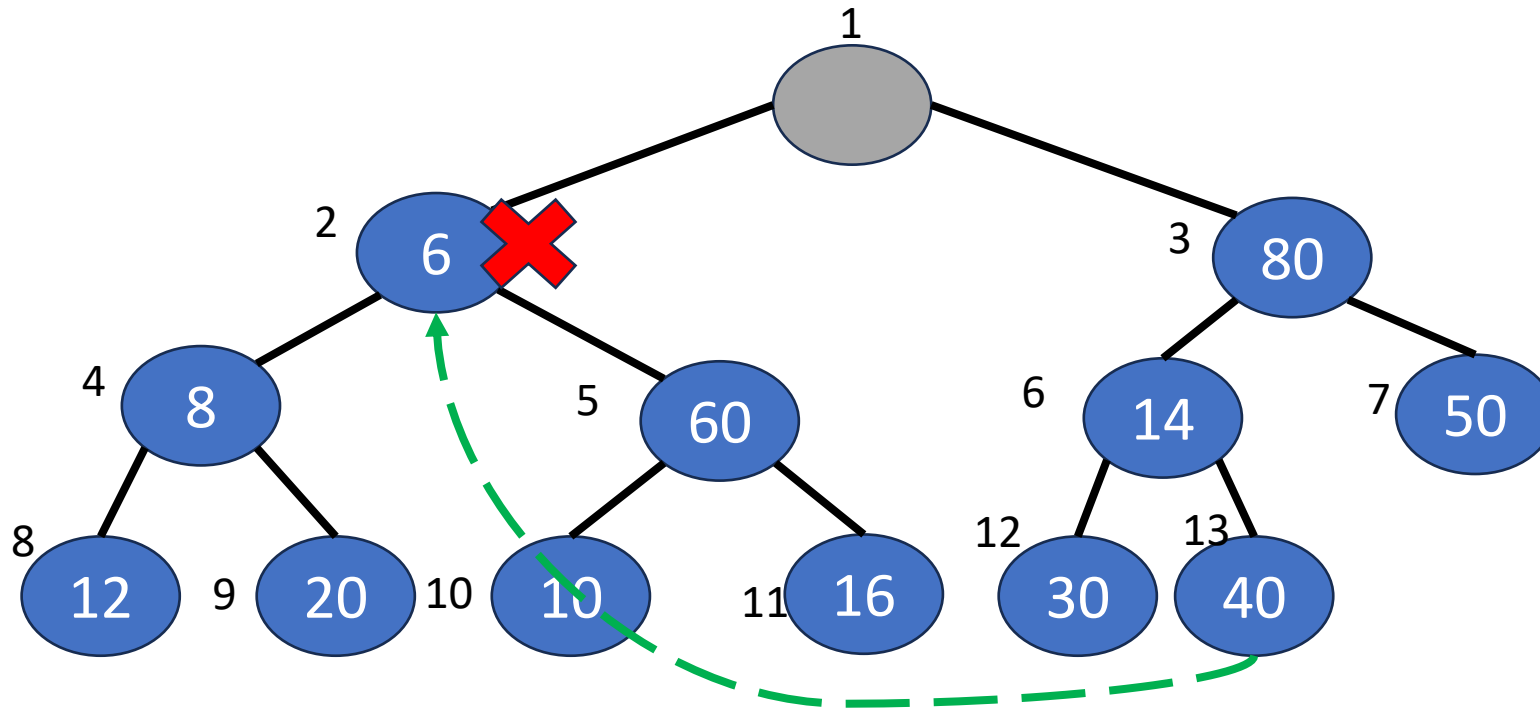
Deap



The node with key 10 is at index 5.

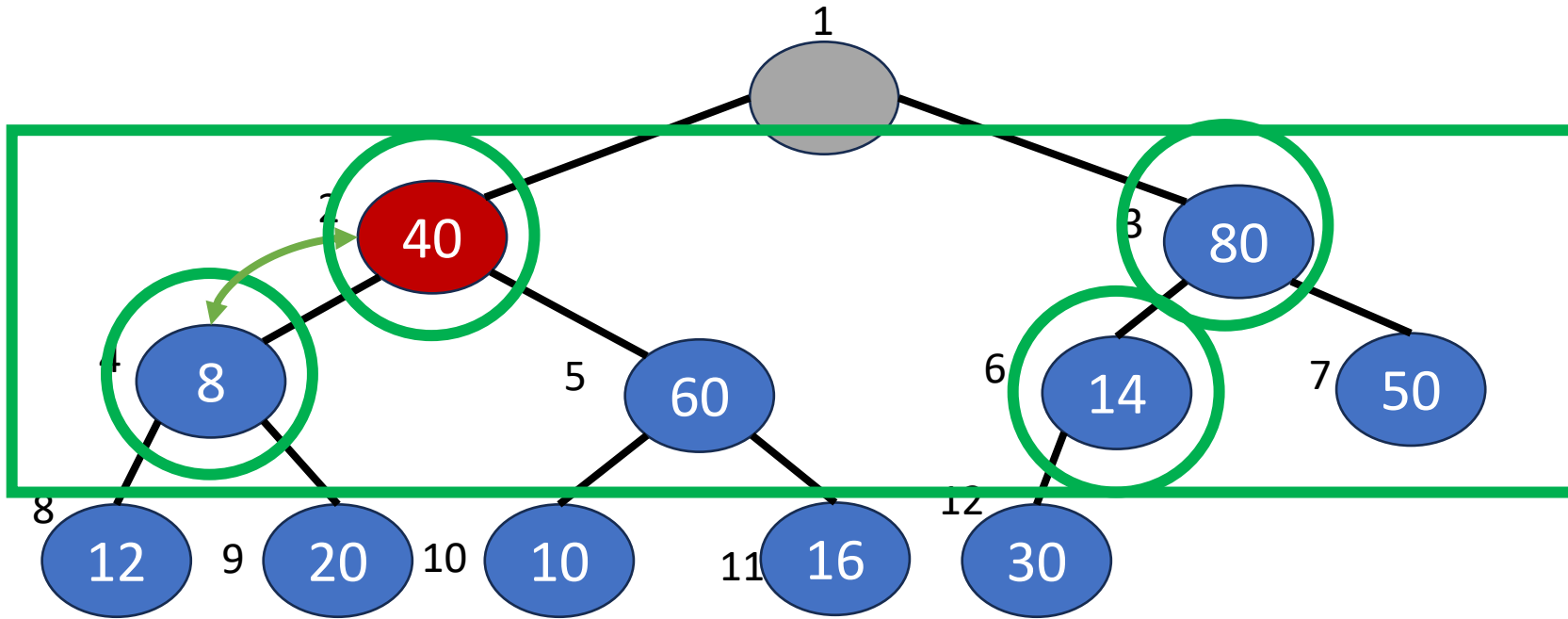
SMMH

- Q4: Perform 3 **delete-min** operation on the following SMMH. Where will be the location of 60?



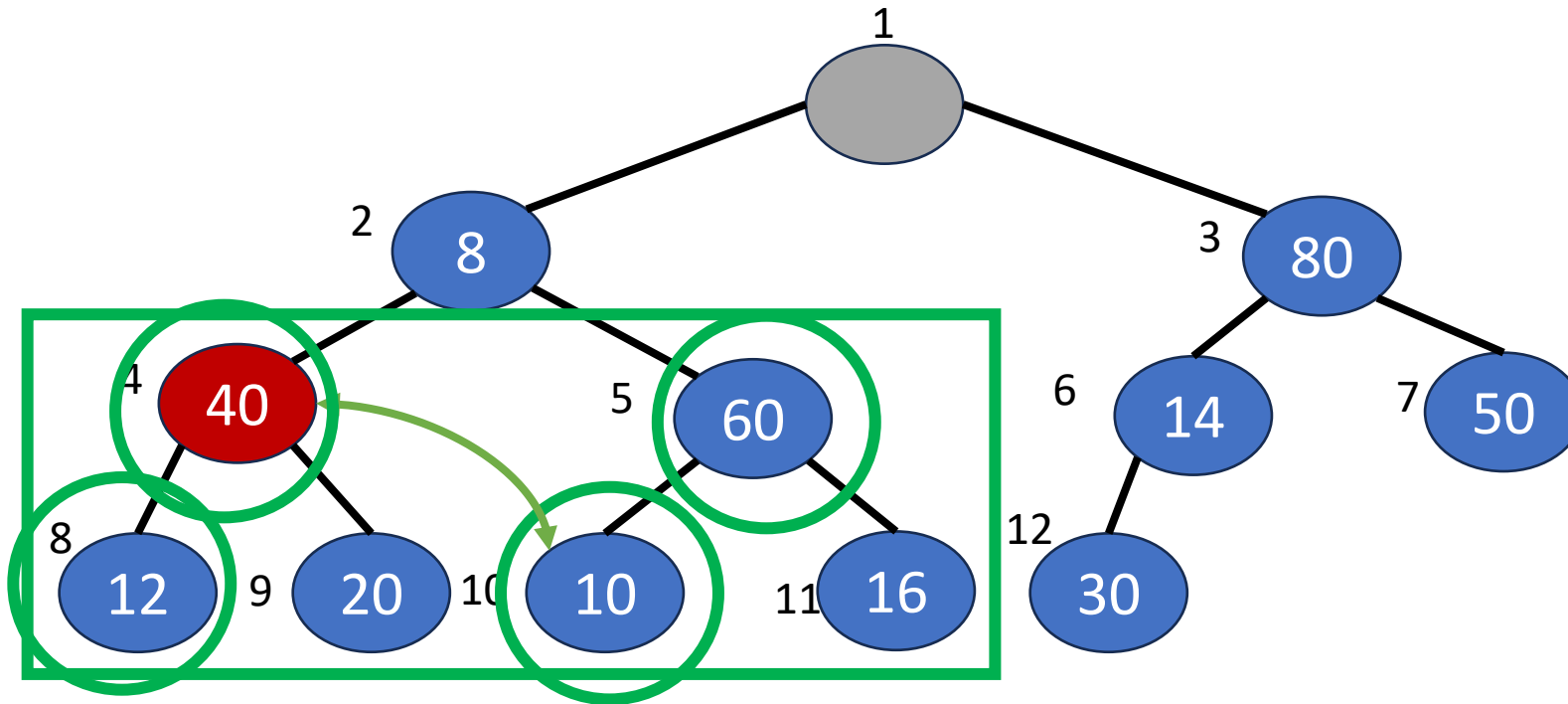
SMMH

- First “delete min”



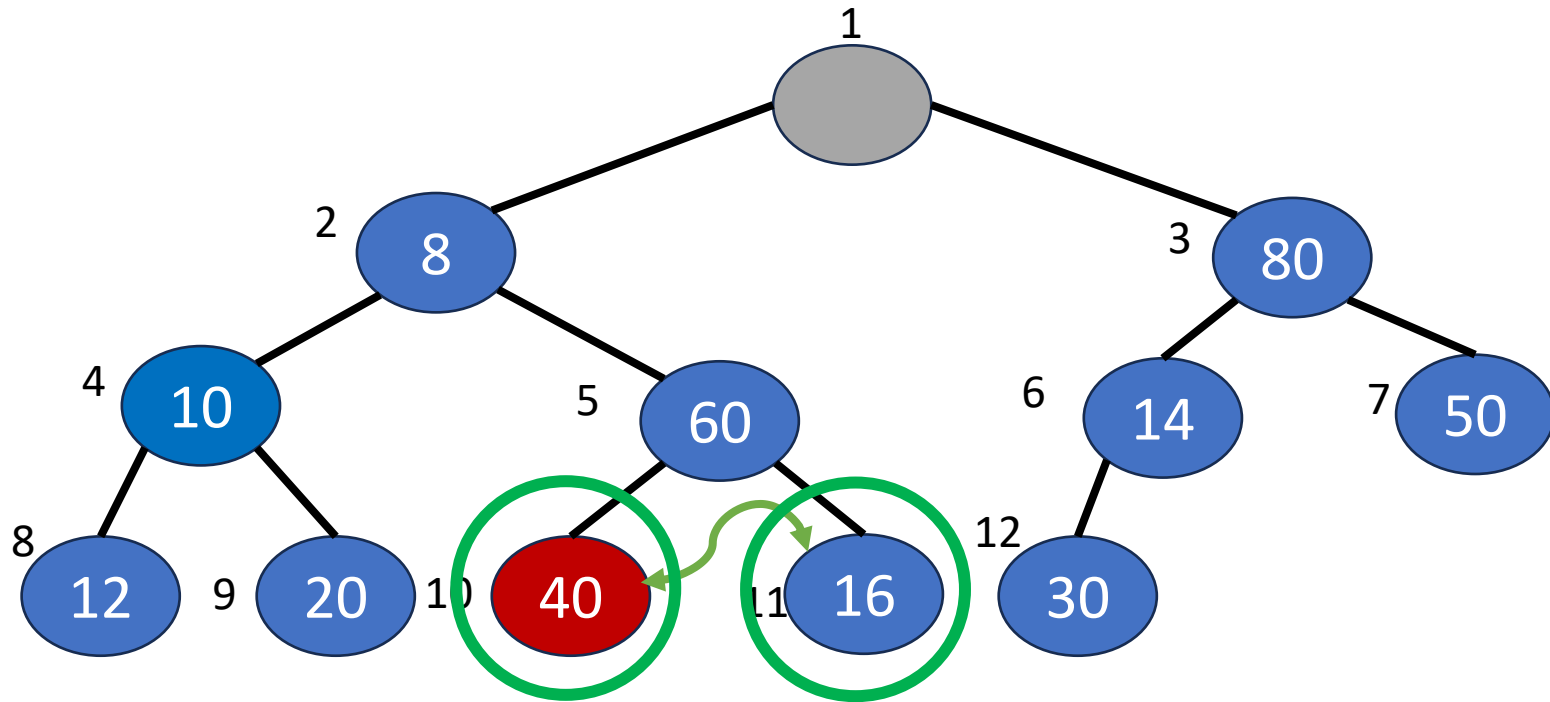
SMMH

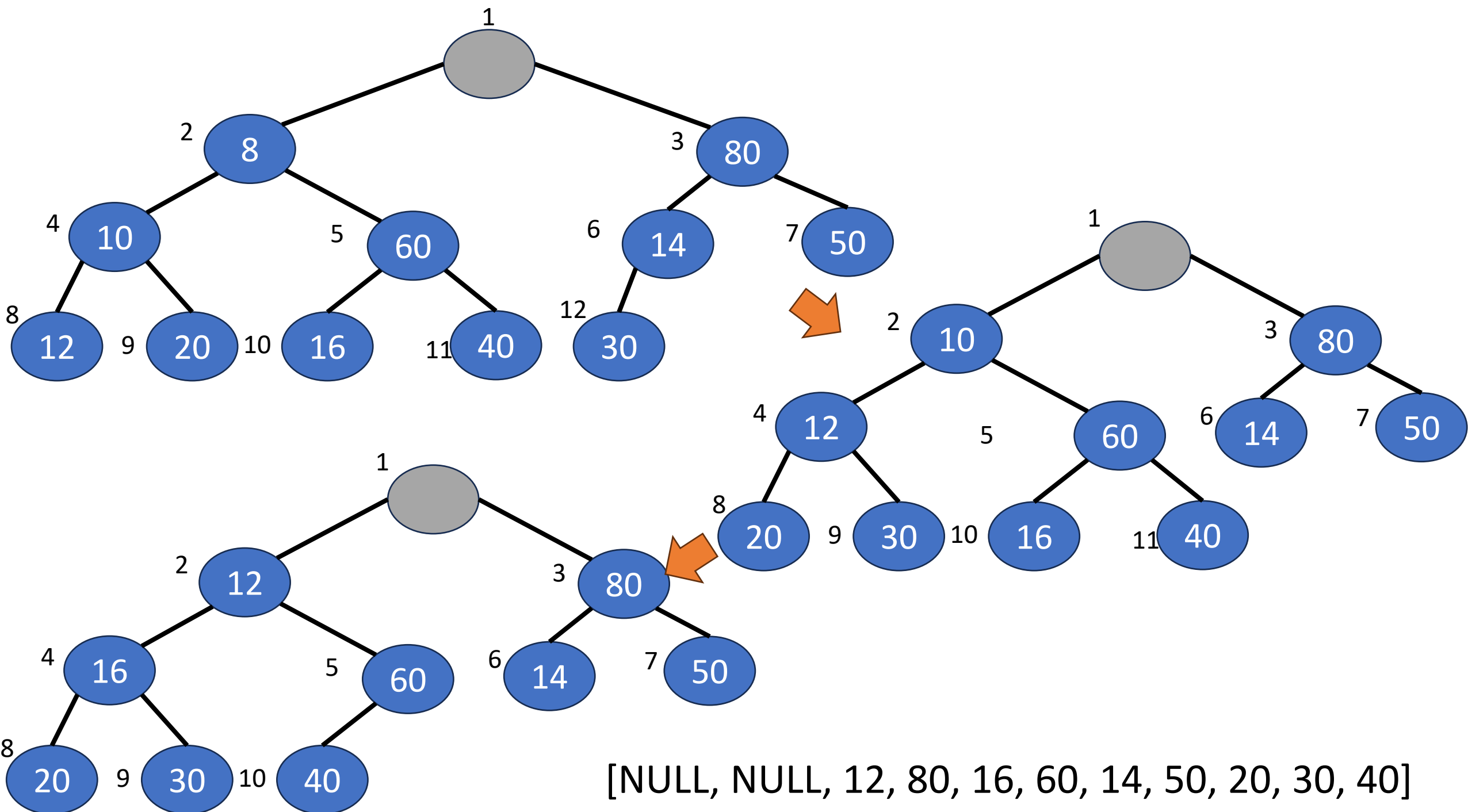
- First “delete min”



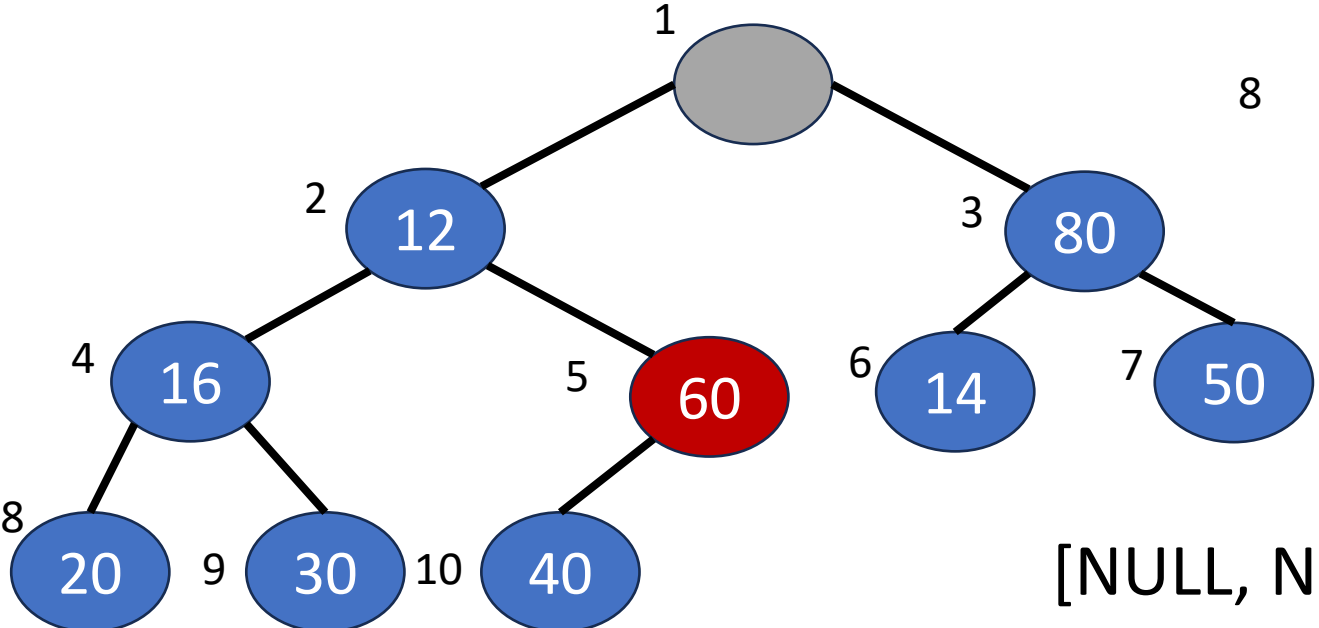
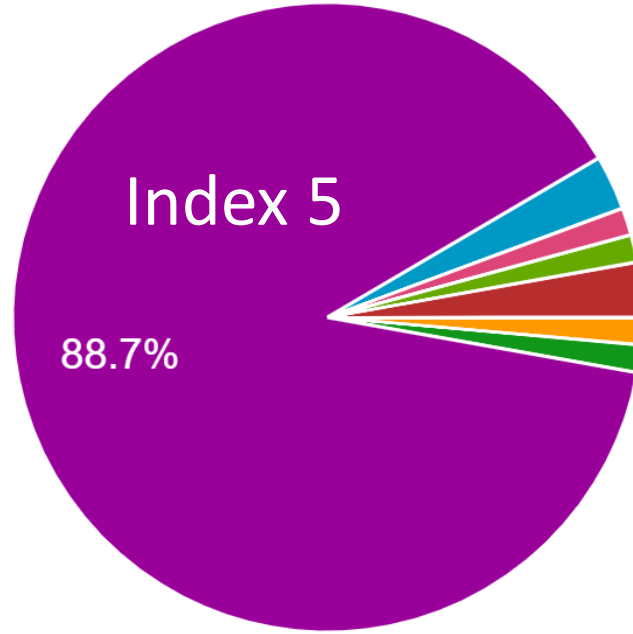
SMMH

- First “delete min”





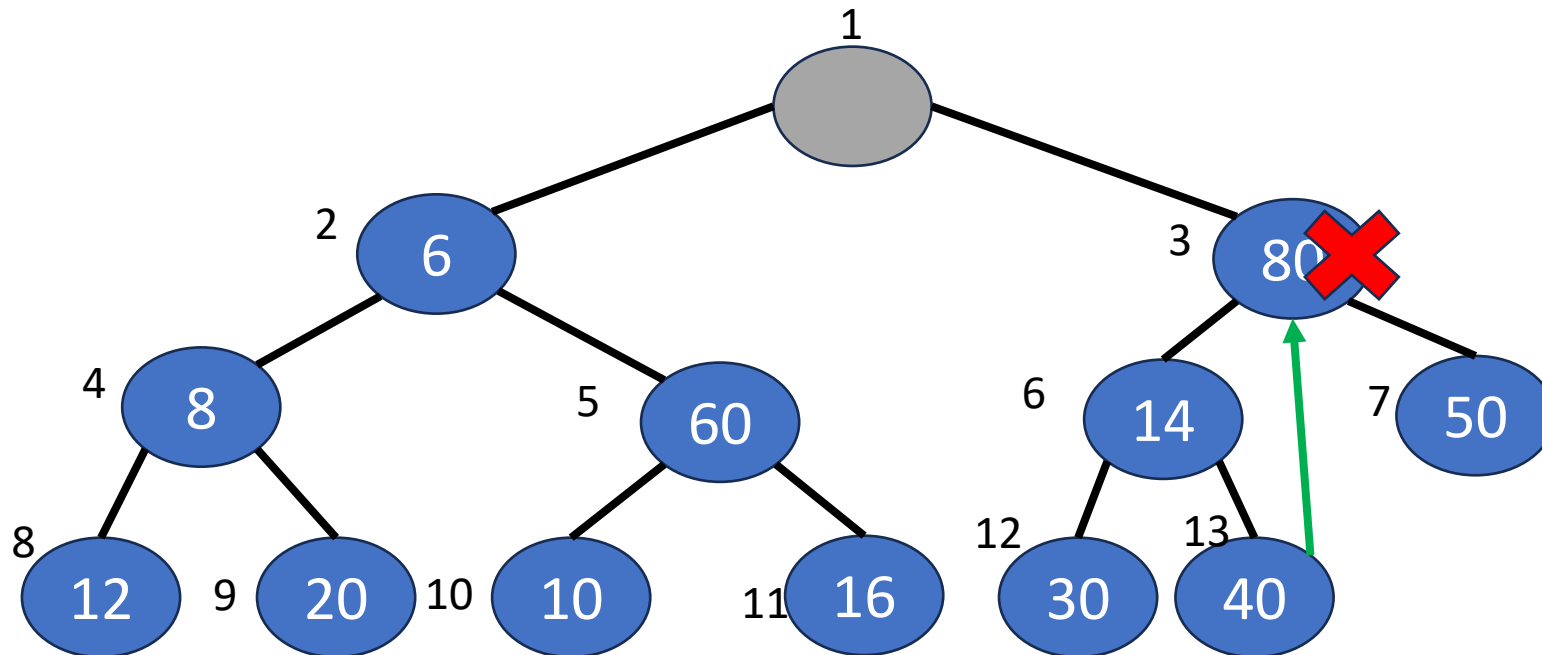
The node with key 60 is at index 5.

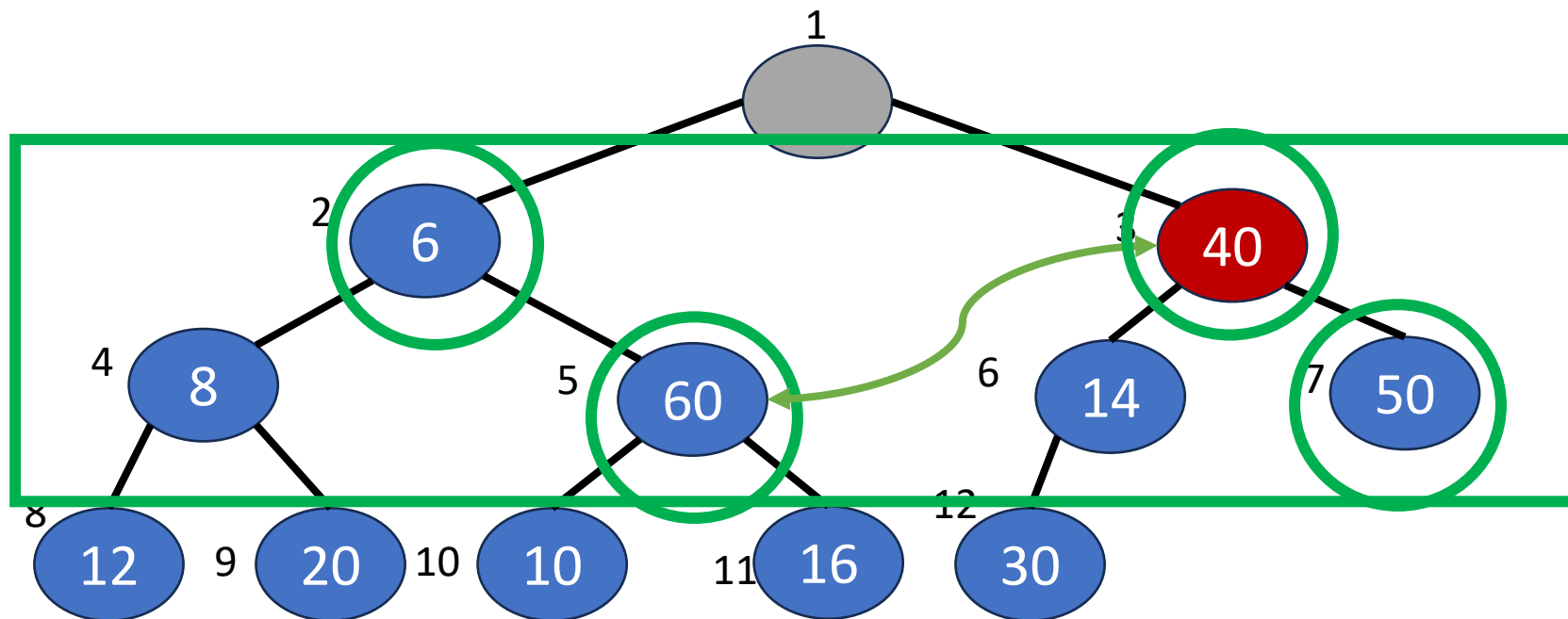


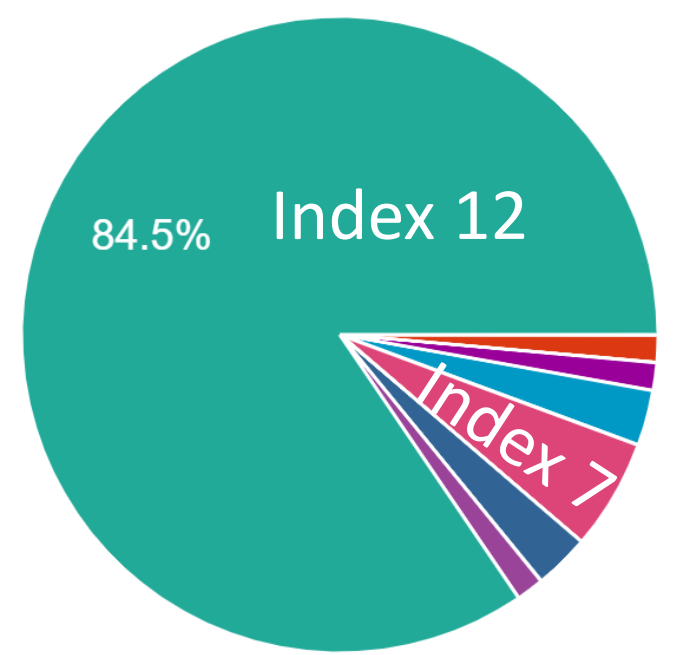
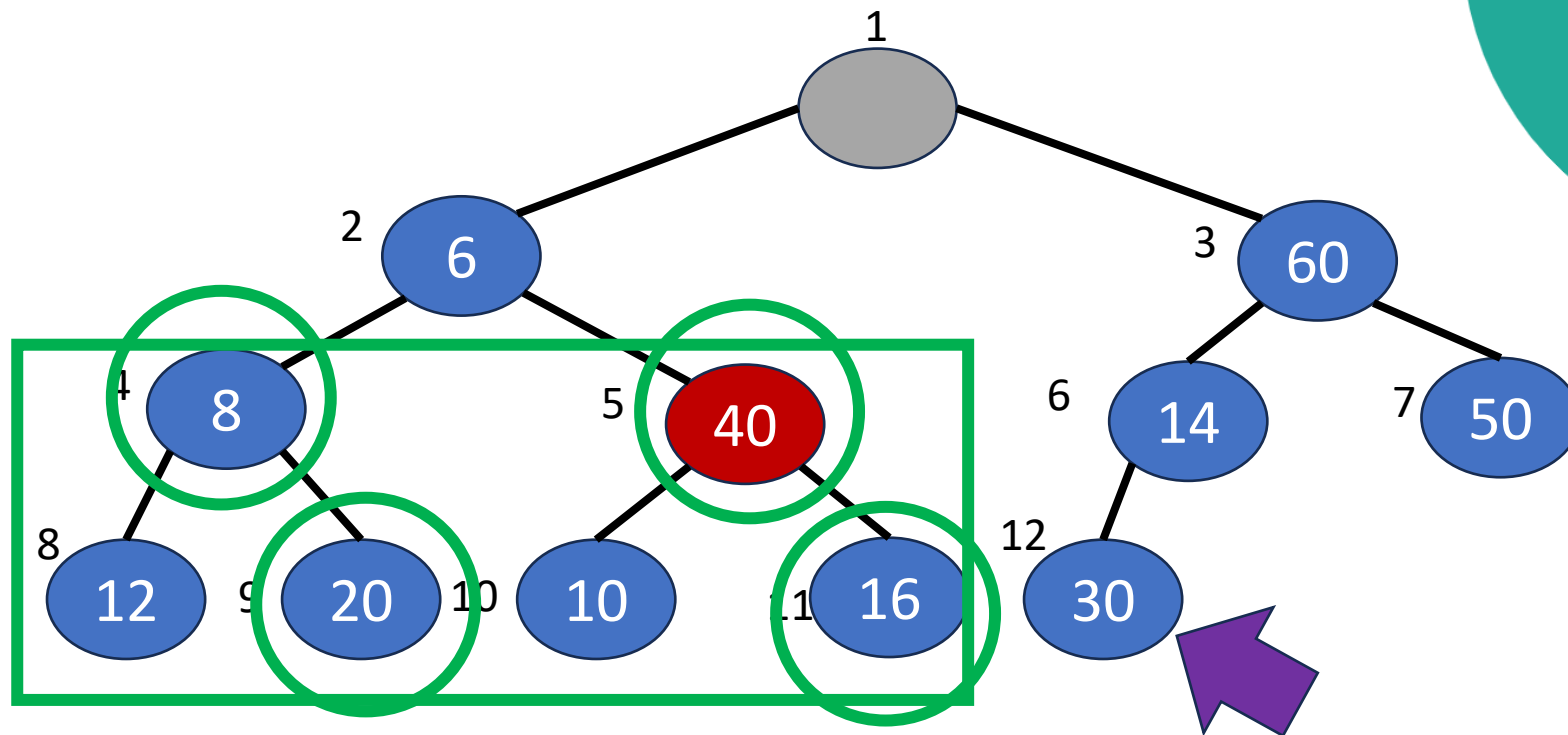
[NULL, NULL, 12, 80, 16, 60, 14, 50, 20, 30, 40]

SMMH

- Q5: Perform a **delete-max** operation on the following SMMH. Where will be the location of 30?







[NULL, NULL, 6, 60, 8, 40, 14, 50, 12, 20, 10, 16, 30]

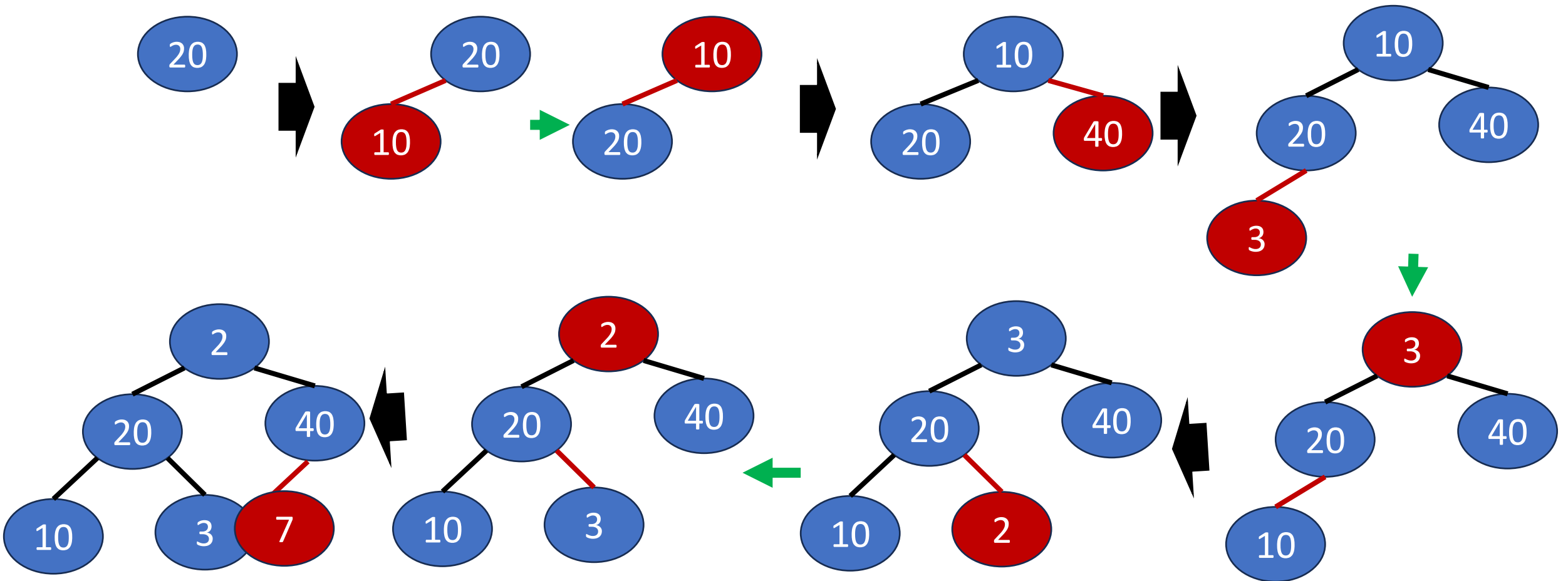
The node with key 30 is at index 12.

Doubly-Ended Priority Queue

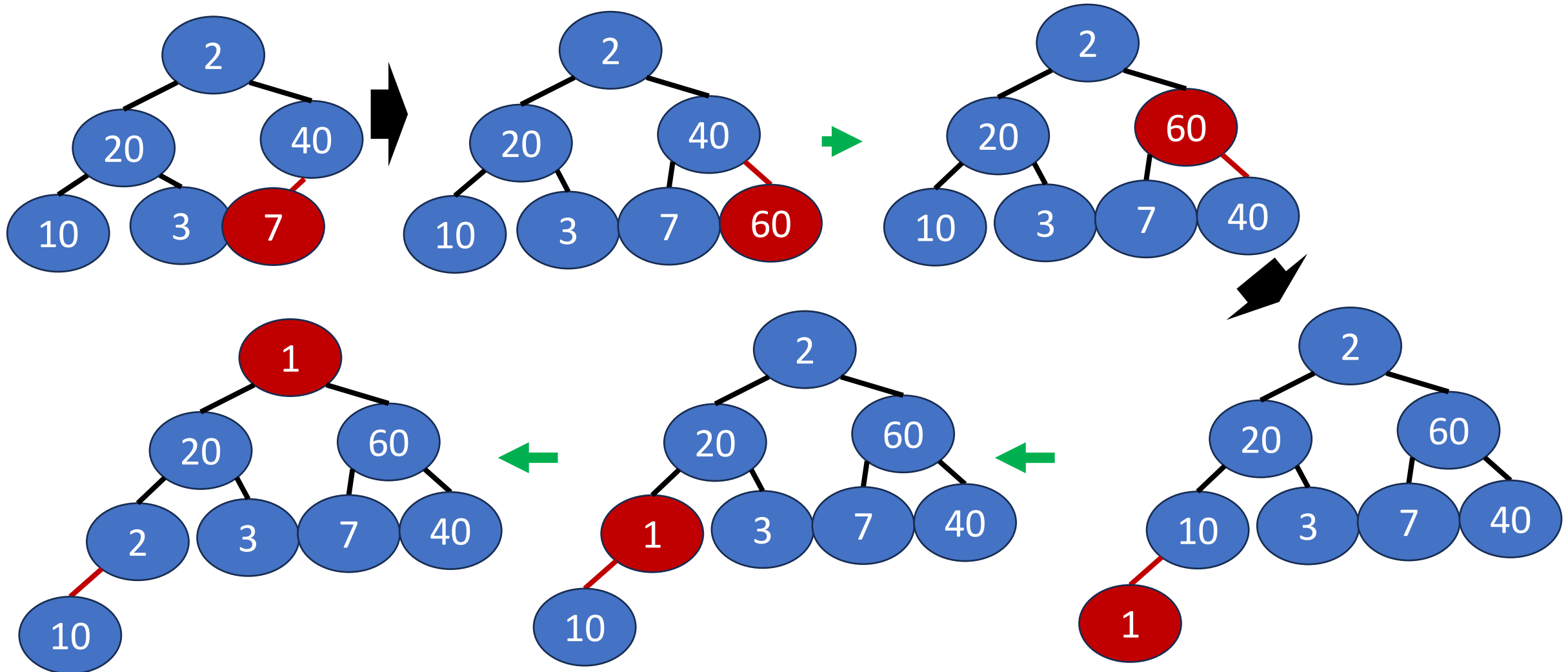
- Given the elements 20, 10, 40, 3, 2, 7, 60, 1, and 80 (in this order).
 - Q6: Insert all elements sequentially into an empty **min-max heap**.
 - Q7: Insert all elements sequentially into an empty **deap**.
 - Q8: Insert all elements sequentially into an empty **SMMH**.

Note: Please write out the resultant heap using array representation (start at index 0).

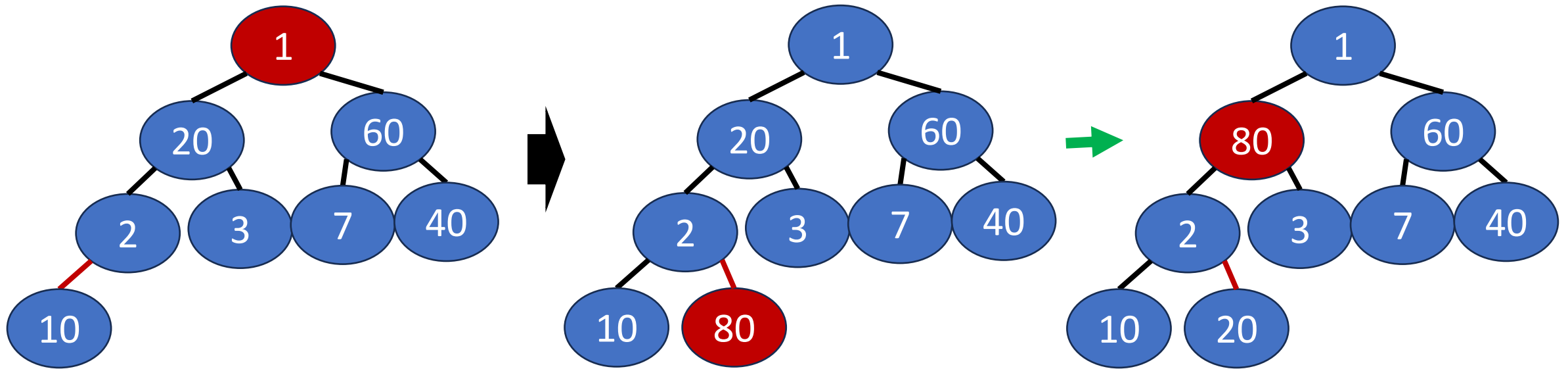
Insert the elements 20, 10, 40, 3, 2, 7, 60, 1, and 80 (in this order) into an empty **min-max heap**.



Insert the elements 20, 10, 40, 3, 2, 7, 60, 1, and 80 (in this order) into an empty **min-max heap**.

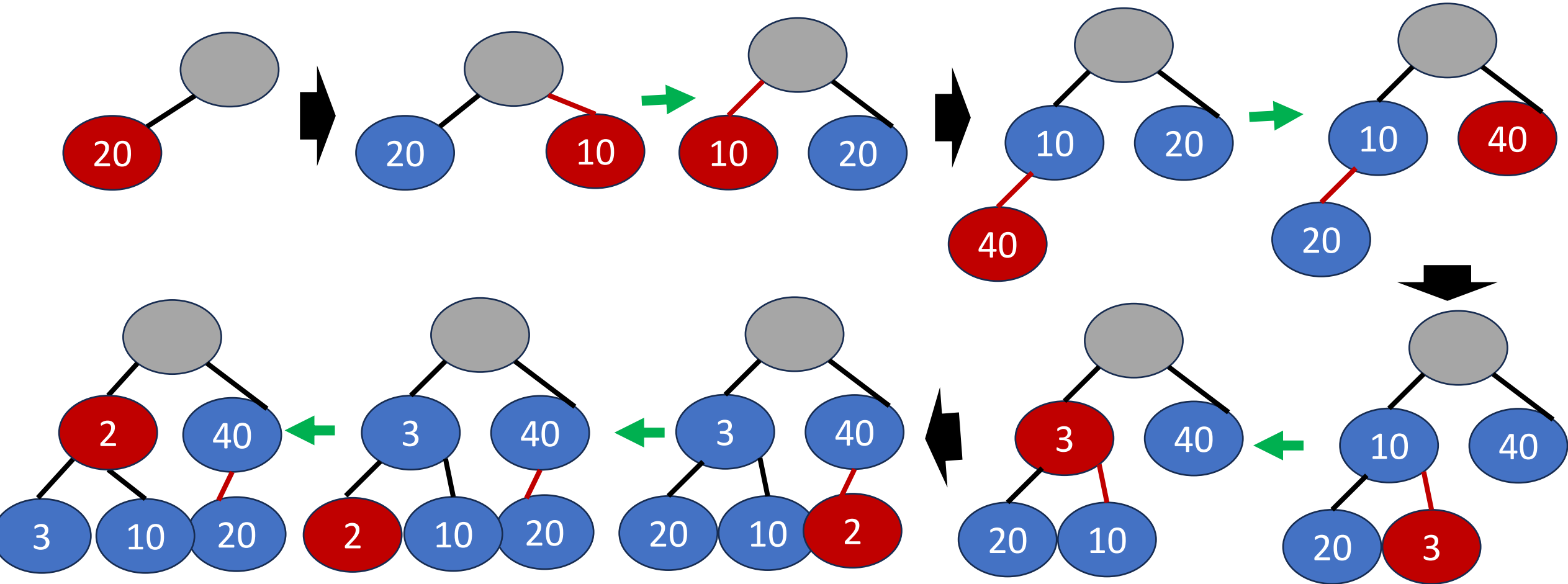


Insert the elements 20, 10, 40, 3, 2, 7, 60, 1, and 80 (in this order) into an empty **min-max heap**.

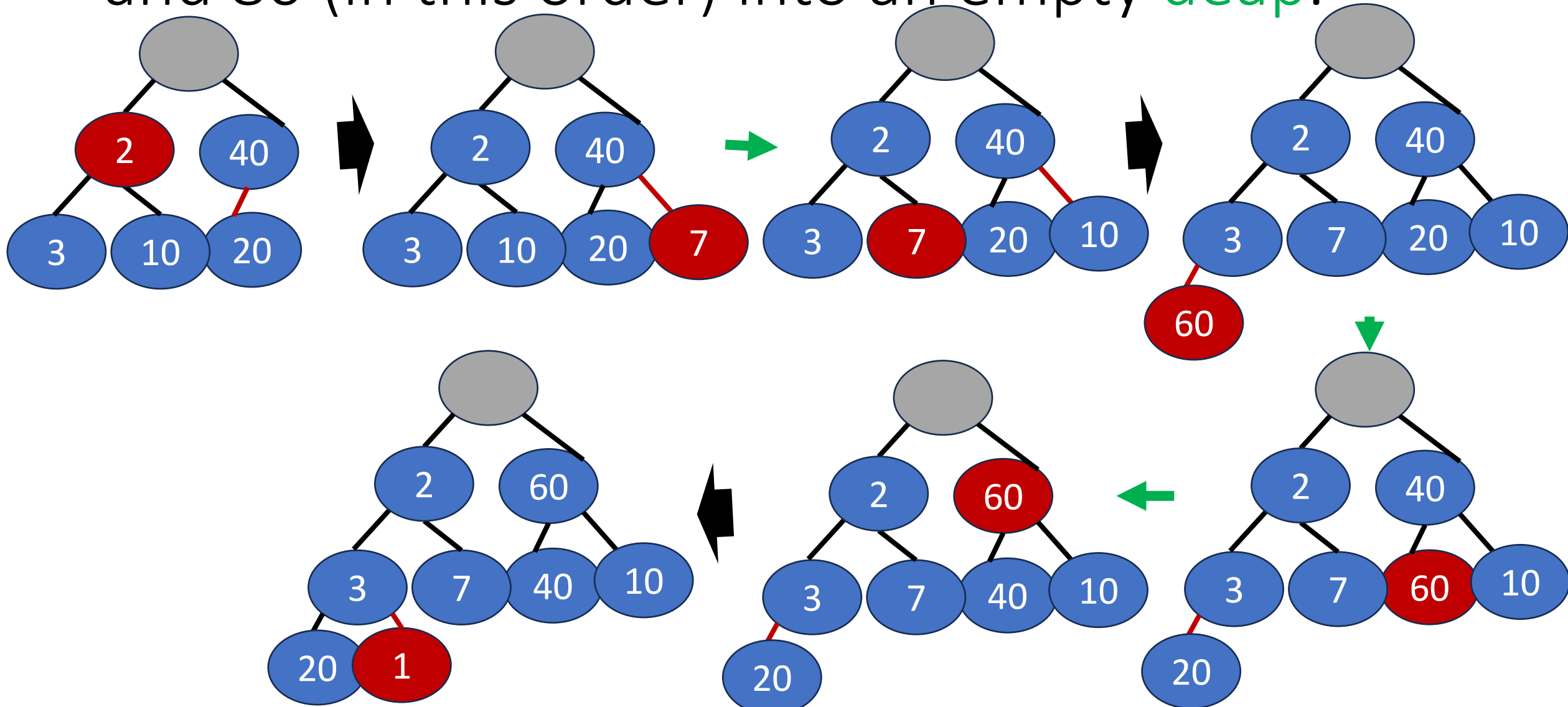


[-, 1, 80, 60, 2, 3, 7, 40, 10, 20]

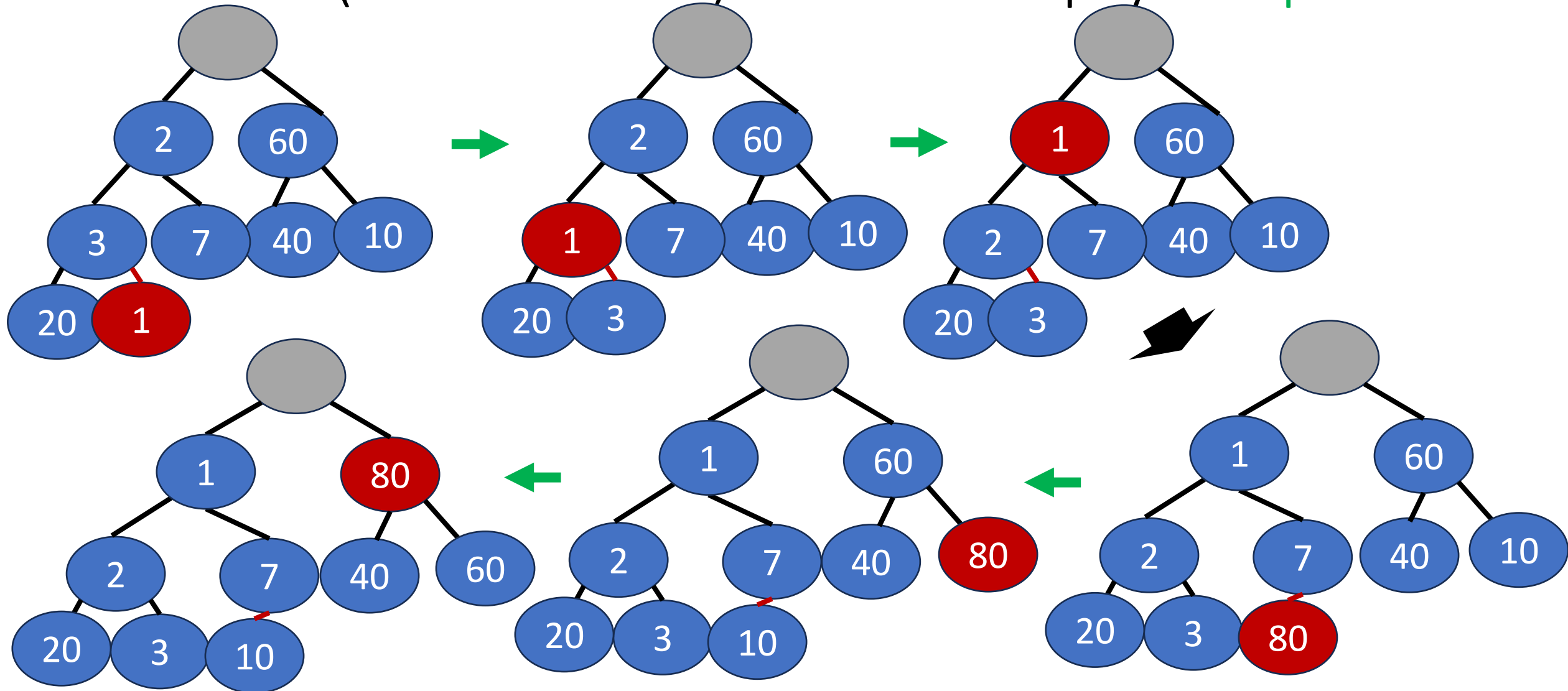
Insert the elements 20, 10, 40, 3, 2, 7, 60, 1, and 80 (in this order) into an empty **deap**.



Insert the elements 20, 10, 40, 3, 2, 7, 60, 1, and 80 (in this order) into an empty **deap**.

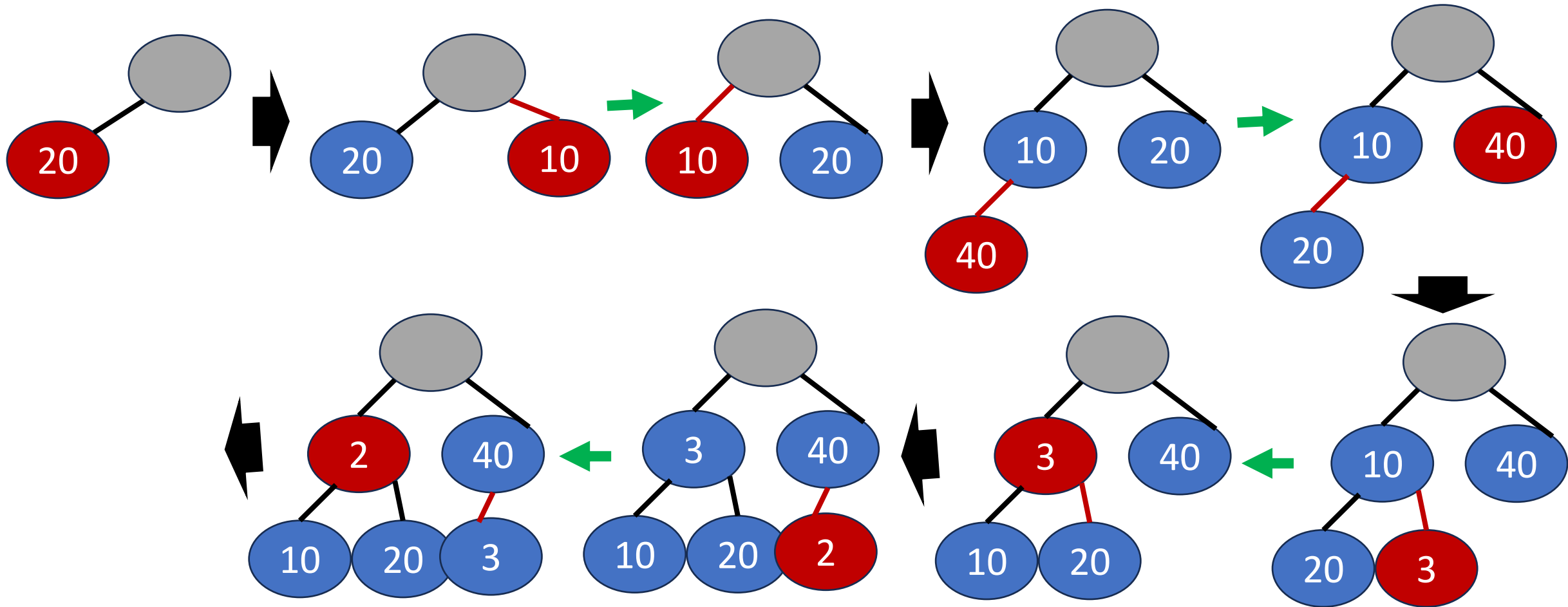


Insert the elements 20, 10, 40, 3, 2, 7, 60, 1, and 80 (in this order) into an empty **deap**.

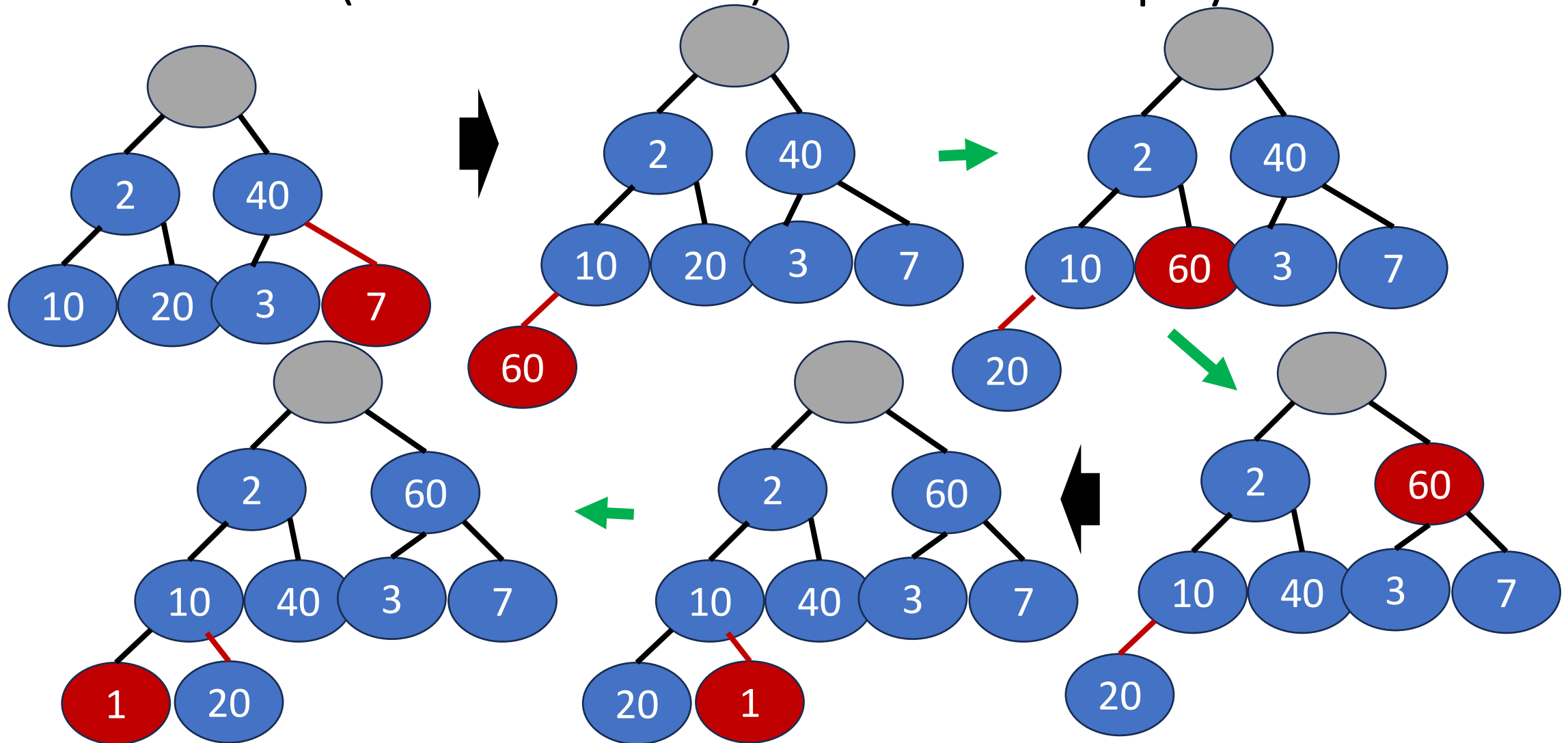


[-, -, 1, 80, 2, 7, 40, 60, 20, 3, 10]

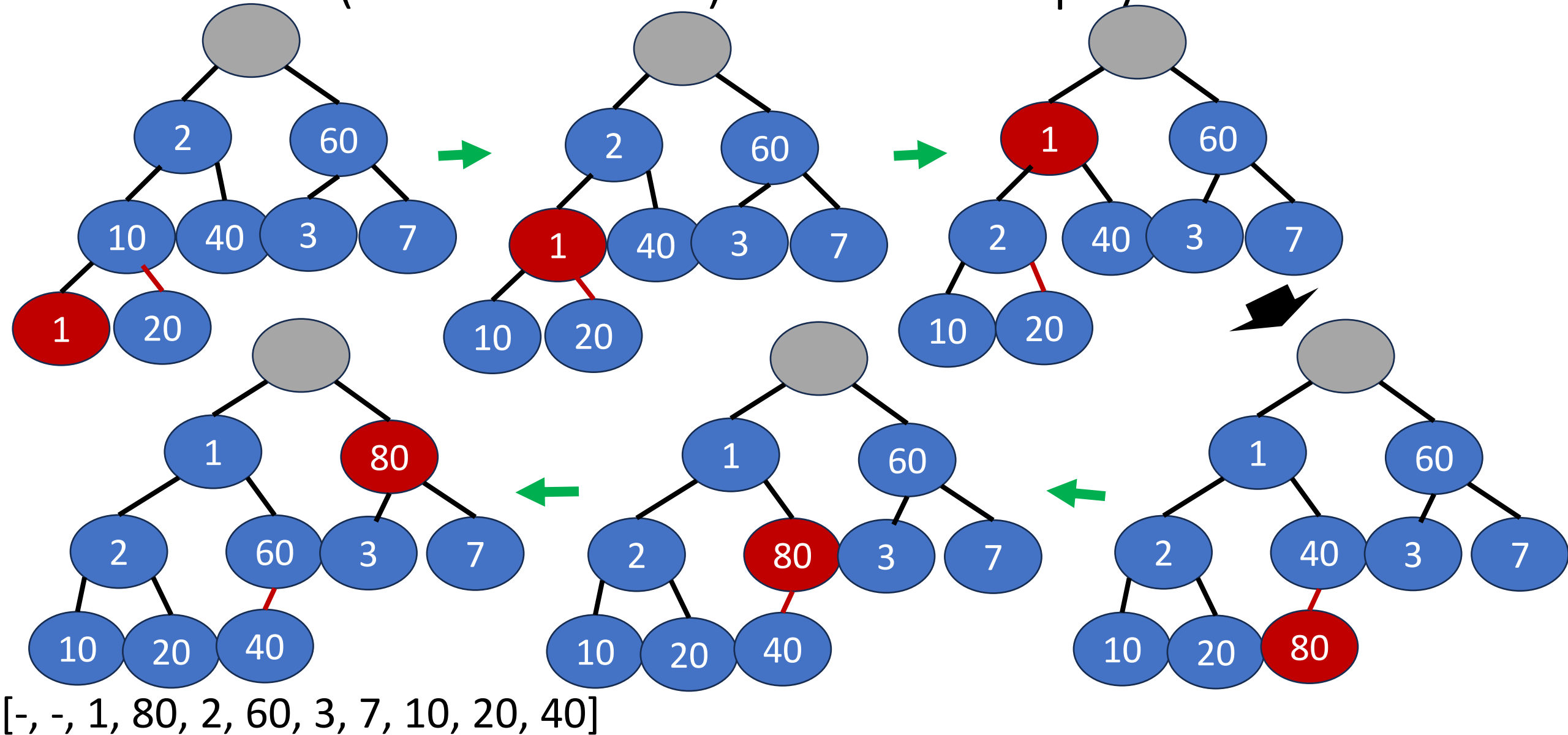
Insert the elements 20, 10, 40, 3, 2, 7, 60, 1, and 80 (in this order) into an empty **SMMH**.



Insert the elements 20, 10, 40, 3, 2, 7, 60, 1, and 80 (in this order) into an empty **SMMH**.



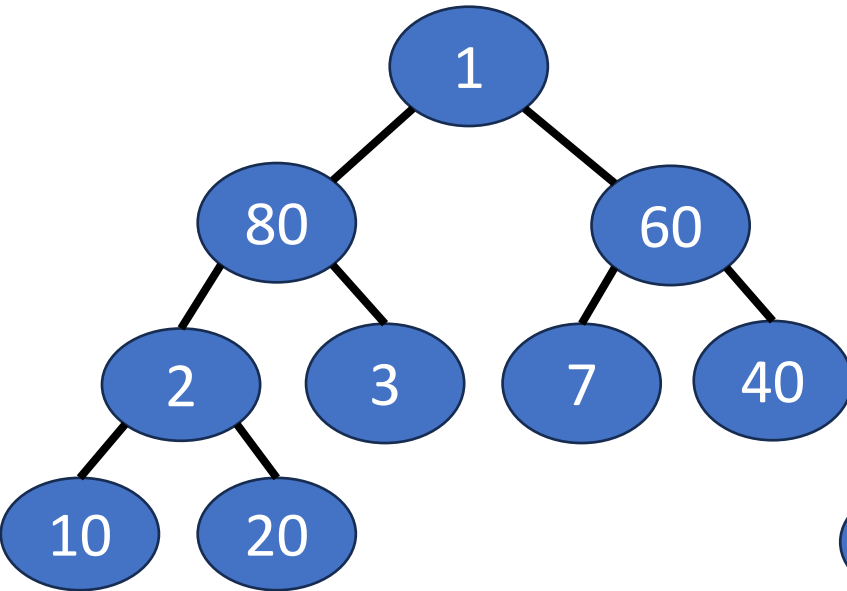
Insert the elements 20, 10, 40, 3, 2, 7, 60, 1, and 80 (in this order) into an empty **SMMH**.



`[-, -, 1, 80, 2, 60, 3, 7, 10, 20, 40]`

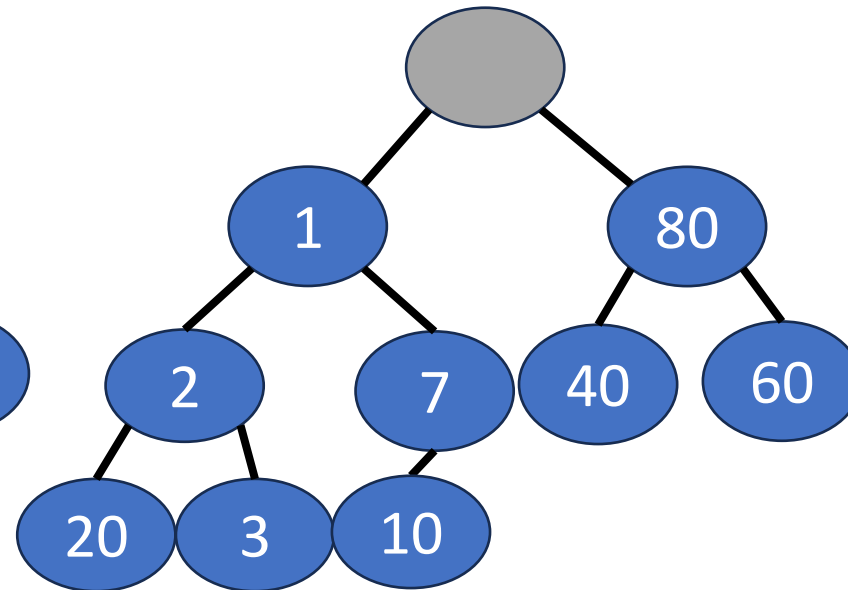
Summary: Insert the elements 20, 10, 40, 3, 2, 7, 60, 1, and 80 into an empty DEPQ.

- Min-max heap



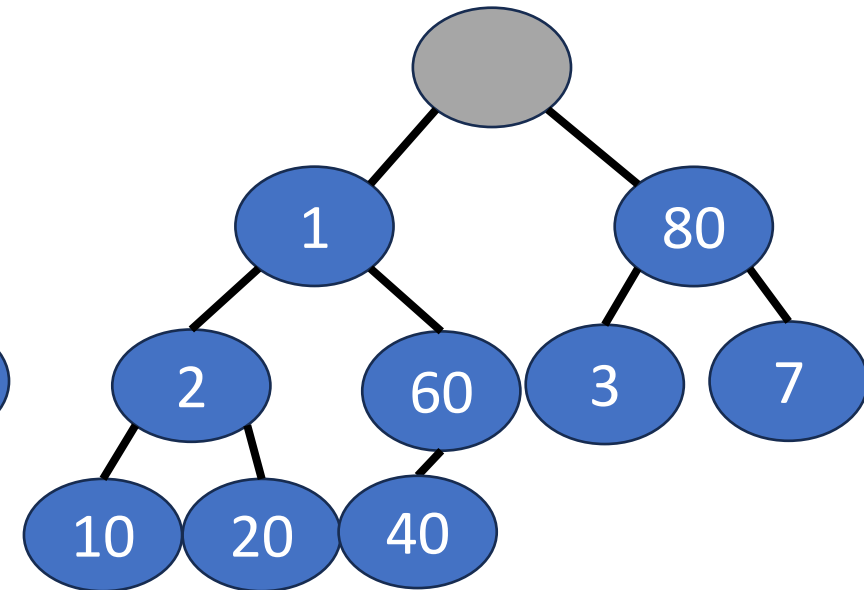
[-, 1, 80, 60, 2, 3, 7, 40, 10, 20]

- Deap



[-, -, 1, 80, 2, 7, 40, 60, 20, 3, 10]

- SMMH



[-, -, 1, 80, 2, 60, 3, 7, 10, 20, 40]

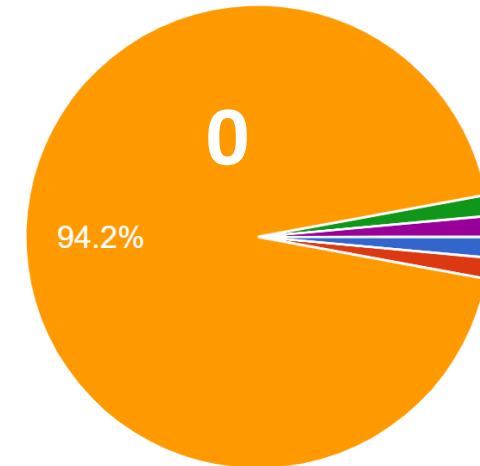
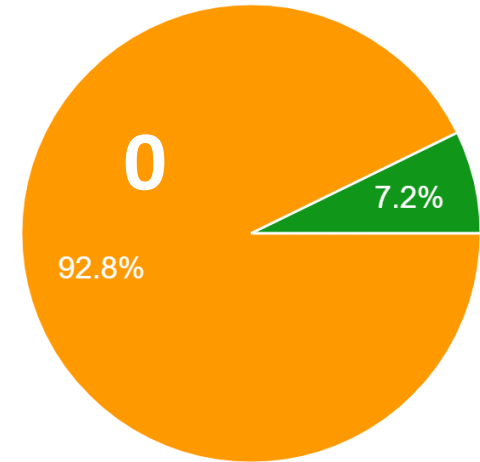
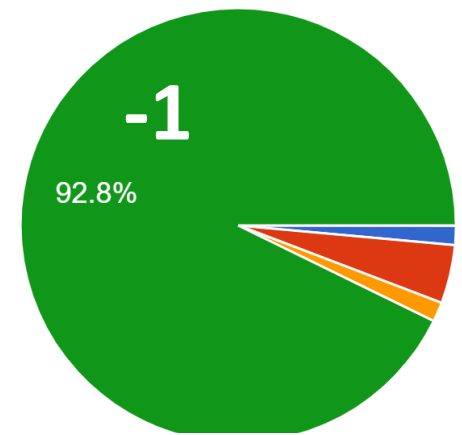
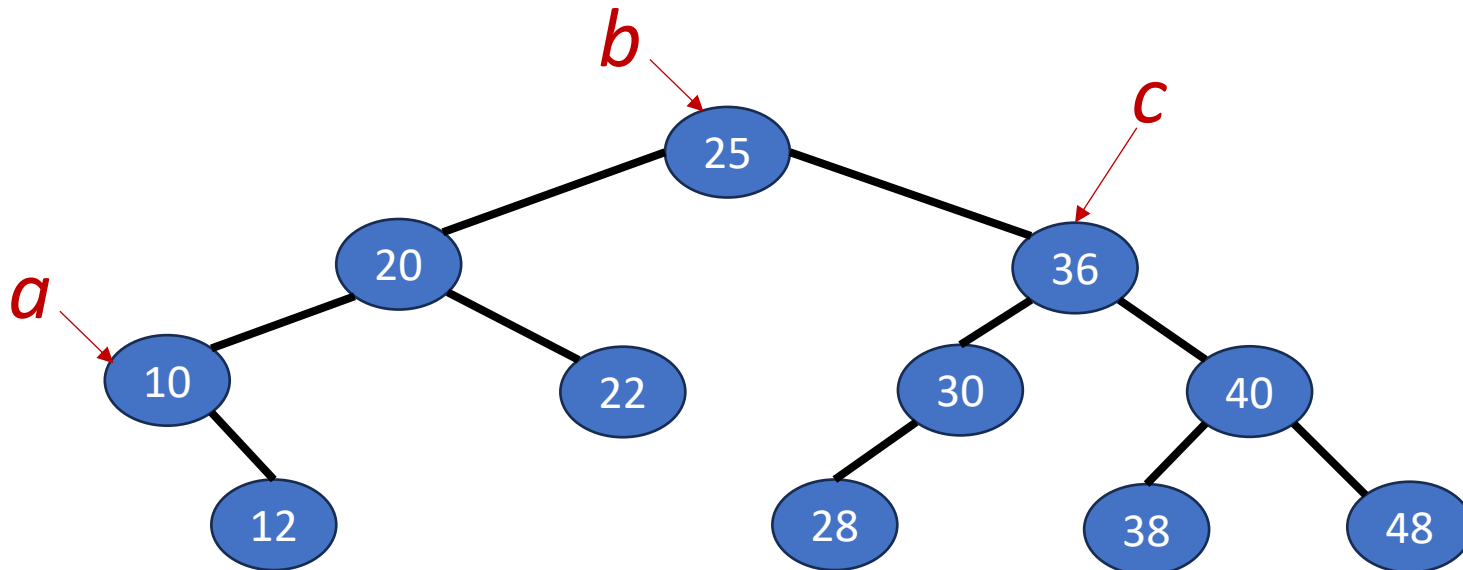
Exercise

- Given the following AVL tree.

Q9: What is the balance factor of Node *a*?

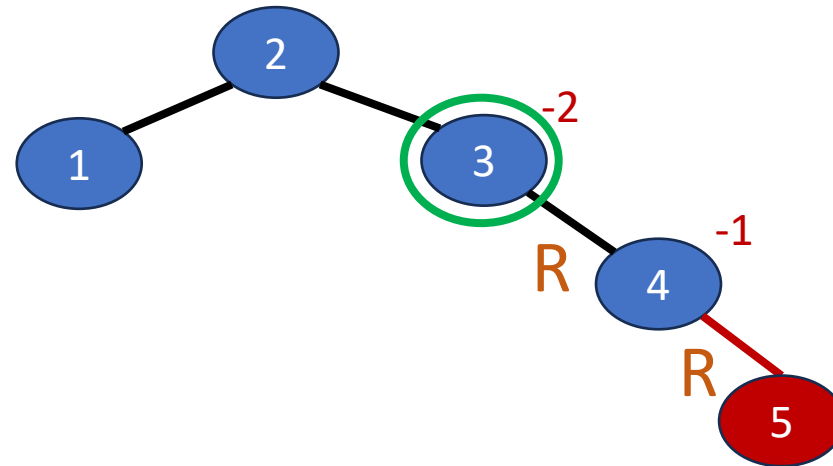
Q10: What is the balance factor of Node *b*?

Q11: What is the balance factor of Node *c*?

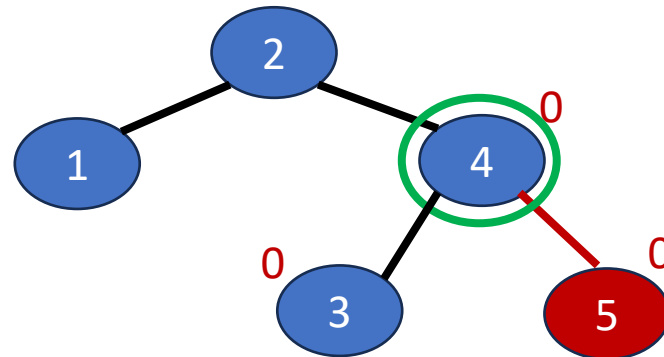


Exercise

- Q12: Please write out the result after inserting 5 into to the following AVL tree.



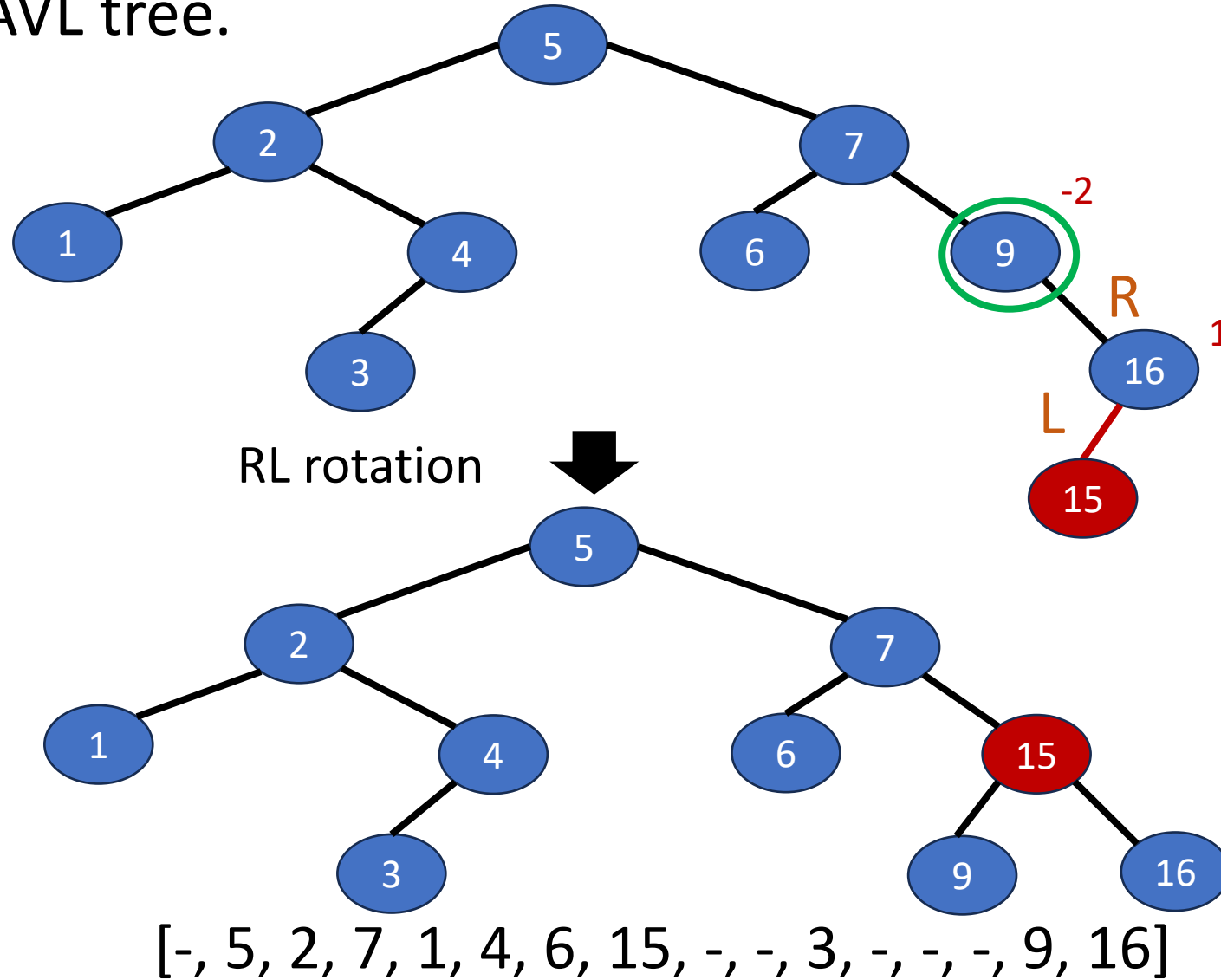
RR rotation



[-, 2, 1, 4, -, -, 3, 5]

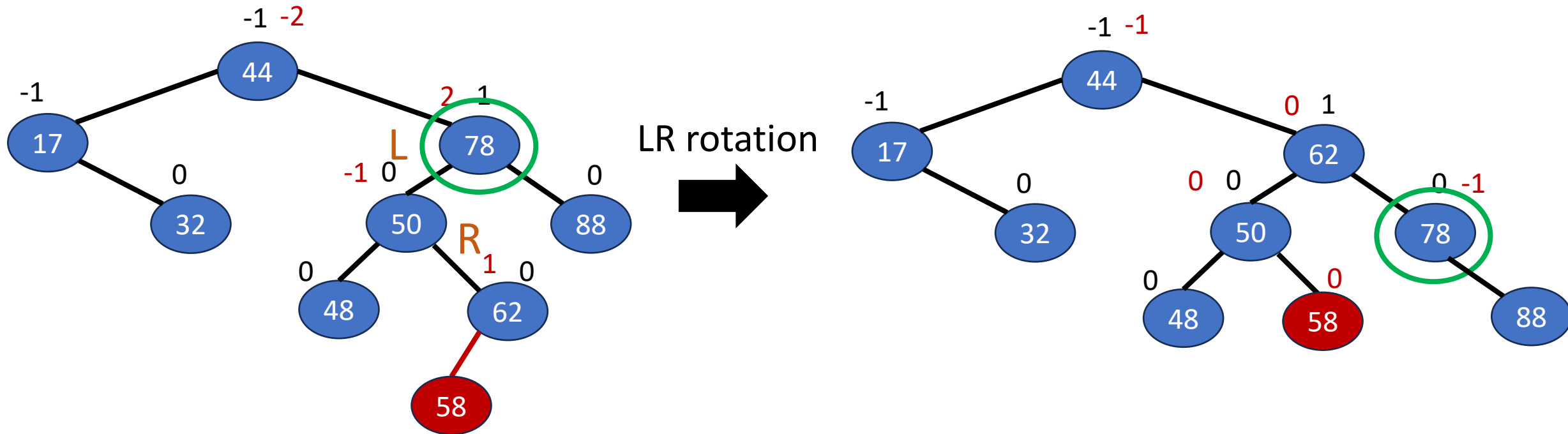
Exercise

- Q13: Please write out the result after inserting 15 into to the following AVL tree.



Exercise

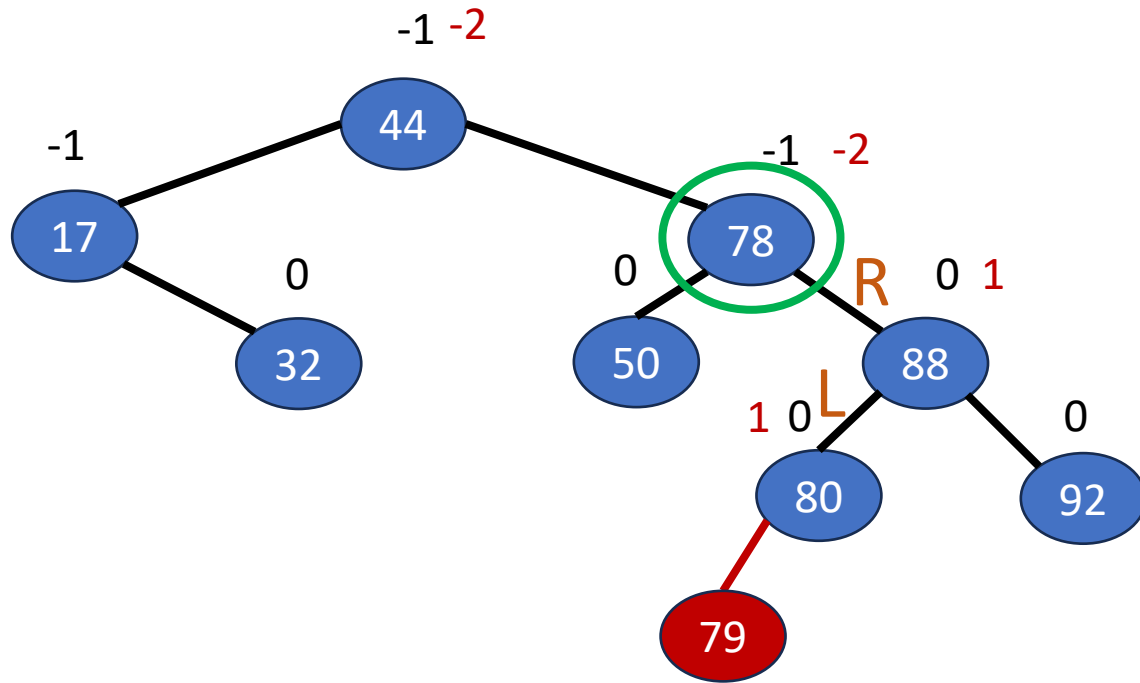
- Q14: Please write out the result after inserting 58 into the following AVL tree.



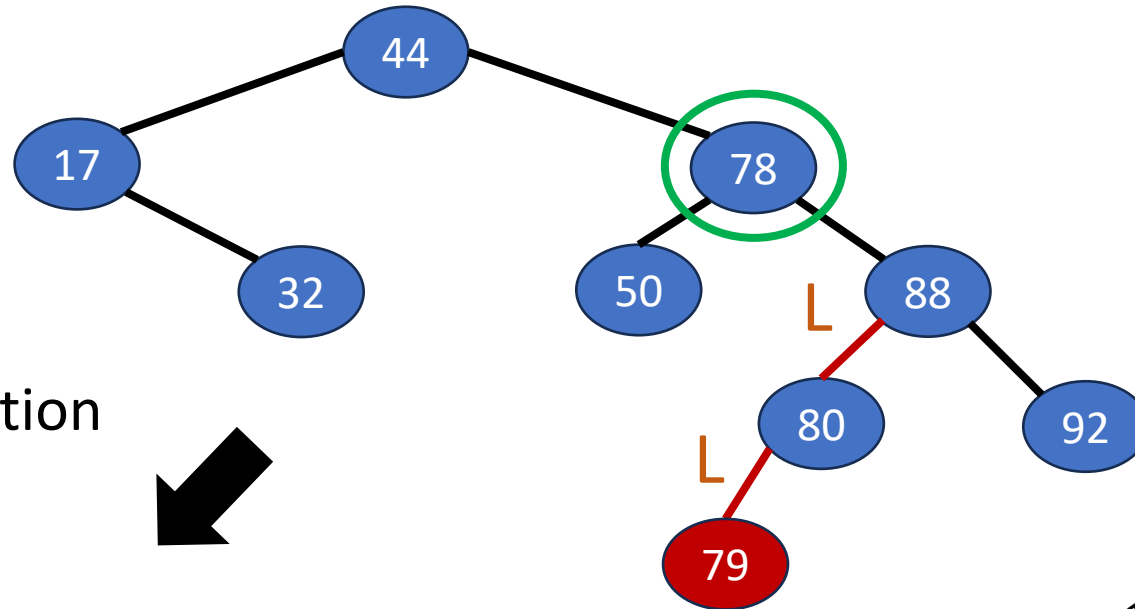
[-, 44, 17, 62, -, 32, 50, 78, -, -, -, -, 48, 58, -, 88]

Exercise

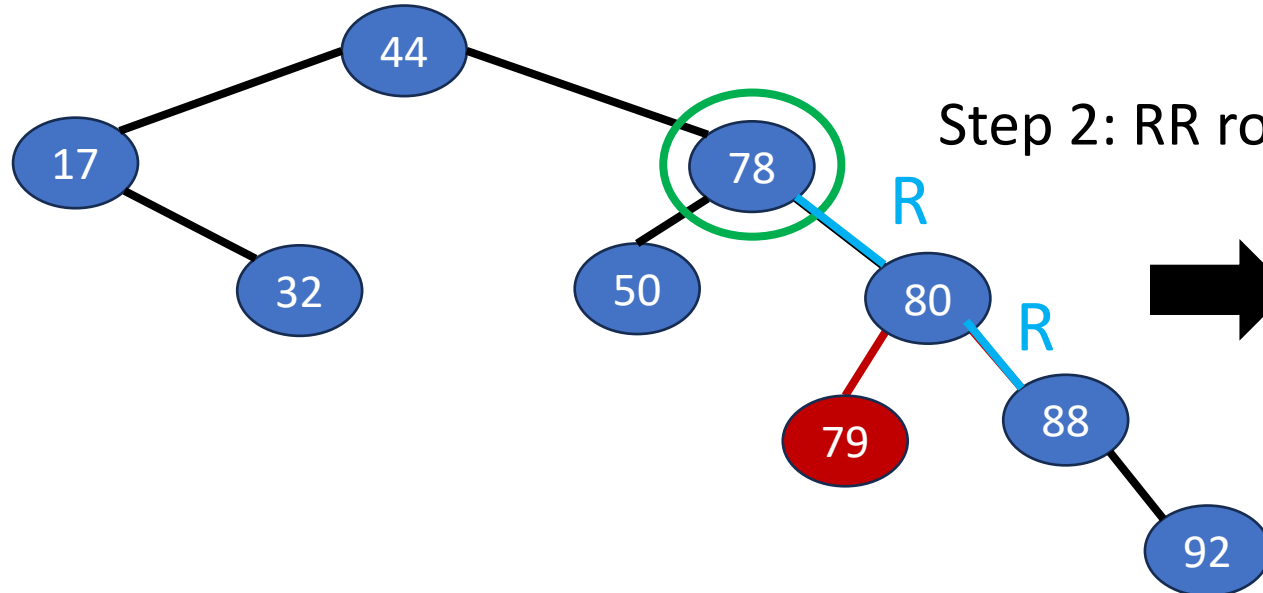
- Q15: Please write out the result after inserting 79 into the following AVL tree.



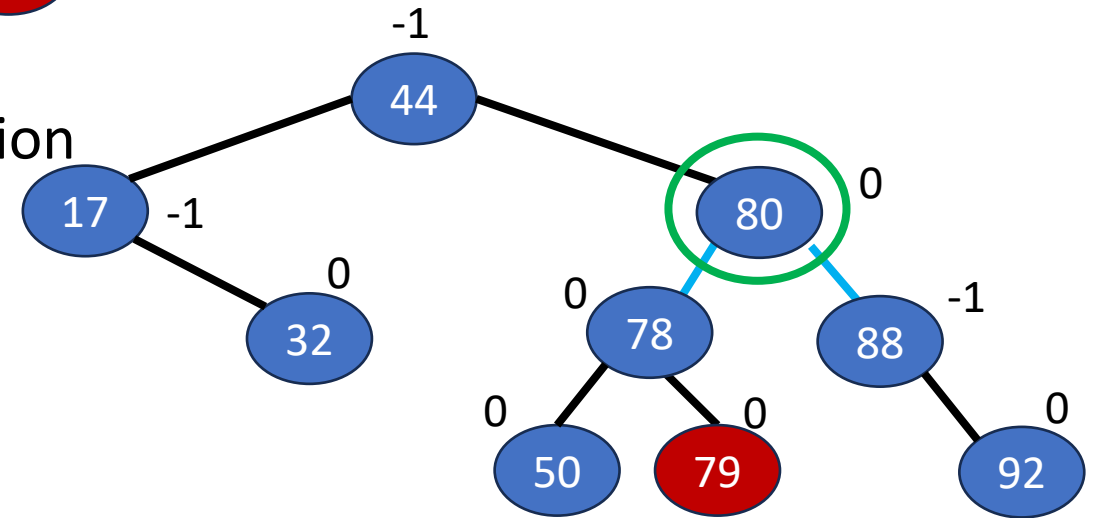
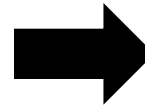
Exercise



Step 1: LL rotation



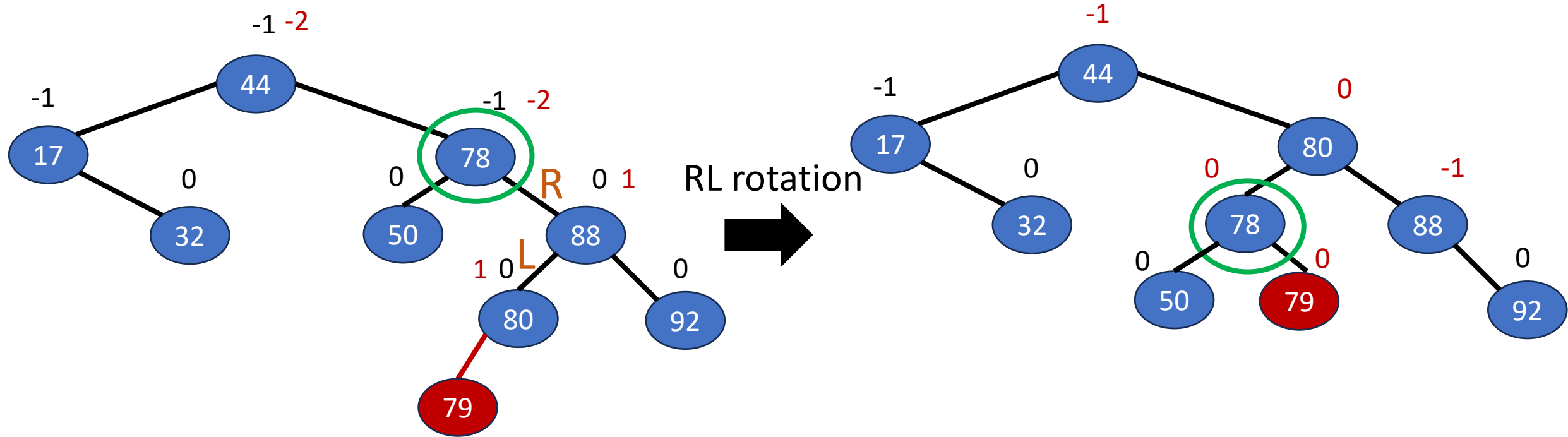
Step 2: RR rotation



`[-, 44, 17, 80, -, 32, 78, 88, -, -, -, -, 50, 79, -, 92]`

Exercise

- Q15: Please write out the result after inserting 79 into the following AVL tree.



[-, 44, 17, 80, -, 32, 78, 88, -, -, -, -, 50, 79, -, 92]