1 Hashing Gone Crazy

For this question, use the following TA class for reference -

```java
public class TA {
    int charisma;
    String name;
    TA(String name, int charisma) {
        this.name = name;
        this.charisma = charisma;
    }
    @Override
    public boolean equals(Object o) {
        TA other = (TA) o;
        return other.name.charAt(0) == this.name.charAt(0);
    }
    @Override
    public int hashCode() {
        return charisma;
    }
}
```

Assume that the `hashCode` of a TA object returns `charisma`, and the `equals` method returns `true` if and only if two TA objects have the same first letter in their name.

Draw the contents of map after the executing the insertions below:

```java
ECHashMap<TA, Integer> map = new ECHashMap<>();
TA sohum = new TA("Sohum", 10);
TA vivant = new TA("Vivant", 20);
map.put(sohum, 1);
map.put(vivant, 2);

vivant.charisma += 2;
map.put(vivant, 3);

sohum.name = "Vohum";
map.put(vivant, 4);

sohum.charisma += 2;
map.put(sohum, 5);

sohum.name = "Sohum";

TA shubha = new TA("Shubha", 24);
map.put(shubha, 6);
```

Assume that the ECHashMap is a HashMap implemented with external chaining as depicted in lecture. The ECHashMap instance begins at size 4 and, for simplicity, does not resize.
2 Buggy Hash

The following classes may contain a bug in one of its methods. Identify those errors and briefly explain why they are incorrect and in which situations would the bug cause problems.

(a) 
```java
class Timezone {
    String timeZone; // "PST", "EST" etc.
    boolean daylight;
    String location;
    ...
    public int currentTime() {
        // return the current time in that time zone
    }
    public int hashCode() {
        return currentTime();
    }
    public boolean equals(Object o) {
        Timezone tz = (Timezone) o;
        return tz.timeZone.equals(timeZone);
    }
}
```

(b) 
```java
class Course {
    int courseCode;
    int yearOffered;
    String[] staff;
    ...
    public int hashCode() {
        return yearOffered + courseCode;
    }
    public boolean equals(Object o) {
        Course c = (Course) o;
        return c.courseCode == courseCode;
    }
}
```
3 Semi Sorted Heaps

Given a heap represented as an array, determine if it is a valid min-heap and semi-sorted.

For a min-heap to be semi-sorted, all the elements in the left branch must be smaller than the elements in the right branch. The first element of the min-heap is at index 1, and you can assume the array has length of at least 4 for simplicity.

For e.g. if array \( A = [\ast, 1, 2, 6, 5, 4, 9, 8] \) represents a heap, the method should return true, since 2, 5, 4 in left branch are all less than 6, 9, 8 in right branch.

```java
public static boolean isSemiSortedHeap(int[] arr) {
    int rightTop = ________;
    for (____________) {
        for (____________) {
            _______________
            _______________
            _______________
            _______________
            _______________
            _______________
            }
    }
}
```

4 Min Heaps

Fill in the following blanks related to min-heap -

(a) `removeMin` has a best case runtime of ________ and a worst case runtime of ________.

(b) `insert` has a best case runtime of ________ and a worst case runtime of ________.

(c) A ________ or ________ traversal on a min-heap can output the elements in sorted order.

(d) The fourth smallest element in a min-heap with 1000 distinct elements can appear in ________ places in the heap.

(e) Given a min-heap with \( 2^n - 1 \) distinct elements, for an element -

- to be on the second level it must be less than ________ element(s) and greater than ________ element(s).
- to be on the bottommost level it must be less than ________ element(s) and greater than ________ element(s).