3) a. Without keeping track of the turn, the output becomes interweaved and unreadable. This is because there is no way of keeping track of the processes that are in the CS. So a process can be interrupted while still in the critical section. output:

Thread 0 is starting iteration 1
Thread 1 is starting iteration 1
We hold these truths to be self-evident, that all men are created equal,
that they are endowed by their Creator with certain unalienable Rights,
that among these are Life, Liberty and the pursuit of Happiness.
We hold these truths to be self-evident, that all men are created equal,
Thread 1 is done with iteration 1
Thread 1 is starting iteration 2
that they are endowed by their Creator with certain unalienable Rights,
that among these are Life, Liberty and the pursuit of Happiness.
We hold these truths to be self-evident, that all men are created equal,
that they are endowed by their Creator with certain unalienable Rights,
Thread 0 is done with iteration 1
Thread 0 is starting iteration 2
that among these are Life, Liberty and the pursuit of Happiness.
Thread 1 is done with iteration 2
Thread 1 is starting iteration 3
We hold these truths to be self-evident, that all men are created equal,
We hold these truths to be self-evident, that all men are created equal,
that they are endowed by their Creator with certain unalienable Rights,
that they are endowed by their Creator with certain unalienable Rights,
that among these are Life, Liberty and the pursuit of Happiness.
that among these are Life, Liberty and the pursuit of Happiness.
Thread 1 is done with iteration 3
Thread 1 is starting iteration 4
Thread 0 is done with iteration 2
Thread 0 is starting iteration 3
We hold these truths to be self-evident, that all men are created equal,
We hold these truths to be self-evident, that all men are created equal,
that they are endowed by their Creator with certain unalienable Rights,
that they are endowed by their Creator with certain unalienable Rights,
that among these are Life, Liberty and the pursuit of Happiness.
that among these are Life, Liberty and the pursuit of Happiness.
Thread 1 is done with iteration 4
Thread 1 is starting iteration 5
Thread 0 is done with iteration 3
Thread 0 is starting iteration 4
We hold these truths to be self-evident, that all men are created equal,
We hold these truths to be self-evident, that all men are created equal,
that they are endowed by their Creator with certain unalienable Rights,
that they are endowed by their Creator with certain unalienable Rights,
that among these are Life, Liberty and the pursuit of Happiness.
that among these are Life, Liberty and the pursuit of Happiness.
Thread 0 is done with iteration 4
Thread 0 is starting iteration 5
Thread 1 is done with iteration 5
We hold these truths to be self-evident, that all men are created equal,
that they are endowed by their Creator with certain unalienable Rights,
that among these are Life, Liberty and the pursuit of Happiness.
Thread 0 is done with iteration 5

b) With Dekker's algorithm, we set up a block so that if a process is in the CS, all other process must wait until the first leaves before entering. This way, our output is coherent because only 1 process outputs at a time.

```
// Entry protocol for Q1b
flag[id] = true;
while (flag[j] == true){
      if (turn != id) {
            flag[id]=false;
            while (turn != id) {};
            flag[id]=true;
      }
}

// Critical Section goes here
// Exit protocol
turn = j;
flag[id] = false;
```

output using the above entry/exit protocols:
Thread 1 is starting iteration 1
We hold these truths to be self-evident, that all men are created equal,
that they are endowed by their Creator with certain unalienable Rights,
that among these are Life, Liberty and the pursuit of Happiness.
Thread 1 is done with iteration 1
Thread 0 is starting iteration 1
We hold these truths to be self-evident, that all men are created equal,
that they are endowed by their Creator with certain unalienable Rights,
that among these are Life, Liberty and the pursuit of Happiness.
Thread 0 is done with iteration 1
Thread 1 is starting iteration 2
We hold these truths to be self-evident, that all men are created equal,
that they are endowed by their Creator with certain unalienable Rights,
that among these are Life, Liberty and the pursuit of Happiness.
Thread 1 is done with iteration 2
Thread 1 is starting iteration 3
We hold these truths to be self-evident, that all men are created equal,
that they are endowed by their Creator with certain unalienable Rights,
that among these are Life, Liberty and the pursuit of Happiness.
Thread 1 is done with iteration 3
Thread 1 is starting iteration 4
We hold these truths to be self-evident, that all men are created equal,
that they are endowed by their Creator with certain unalienable Rights,
that among these are Life, Liberty and the pursuit of Happiness.
Thread 1 is done with iteration 4
Thread 0 is starting iteration 2
We hold these truths to be self-evident, that all men are created equal,
that they are endowed by their Creator with certain unalienable Rights,
that among these are Life, Liberty and the pursuit of Happiness.
Thread 0 is done with iteration 2
Thread 0 is starting iteration 3
We hold these truths to be self-evident, that all men are created equal,
that they are endowed by their Creator with certain unalienable Rights,
that among these are Life, Liberty and the pursuit of Happiness.
Thread 0 is done with iteration 3

Thread 1 is starting iteration 5
We hold these truths to be self-evident, that all men are created equal,
that they are endowed by their Creator with certain unalienable Rights,
that among these are Life, Liberty and the pursuit of Happiness.
Thread 1 is done with iteration 5
Thread 0 is starting iteration 4
We hold these truths to be self-evident, that all men are created equal,
that they are endowed by their Creator with certain unalienable Rights,
that among these are Life, Liberty and the pursuit of Happiness.
Thread 0 is done with iteration 4
Thread 0 is starting iteration 5
We hold these truths to be self-evident, that all men are created equal,
that they are endowed by their Creator with certain unalienable Rights,
that among these are Life, Liberty and the pursuit of Happiness.
Thread 0 is done with iteration 5

c) It is possible for a thread that is in the middle of its entry protocol to be passed by a thread that completes this process faster. If, for example we interrupt a thread right after the busy wait, but before it has a chance to set its flag back to true, other processes can pass the first, and access the CS more than once. If we modify the entry protocol to the following, thread 0 will complete all 5 iterations before thread 1 has a chance to finish the first.

```
// Entry protocol for Q1c
flag[id] = true;
while (flag[j] == true){
      if (turn != id) {
            flag[id]=false;
            while (turn != id) {};
            try { sleep(1000 * id); }
            catch (Exception e) { System.out.println(e); }
            flag[id]=true;
      }
}

// Critical Section goes here
// Exit protocol
turn = j;
flag[id] = false;
```

output using the above entry/exit protocols:
Thread 0 is starting iteration 1
We hold these truths to be self-evident, that all men are created equal,
that they are endowed by their Creator with certain unalienable Rights,
that among these are Life, Liberty and the pursuit of Happiness.
Thread 0 is done with iteration 1

... Thread 0 completes iterations 2,3,4

Thread 0 is starting iteration 5
We hold these truths to be self-evident, that all men are created equal,
that they are endowed by their Creator with certain unalienable Rights,
that among these are Life, Liberty and the pursuit of Happiness.
Thread 0 is done with iteration 5
Thread 1 is starting iteration 1

We hold these truths to be self-evident, that all men are created equal,
that they are endowed by their Creator with certain unalienable Rights,
that among these are Life, Liberty and the pursuit of Happiness.
Thread 1 is done with iteration 1

... Thread 1 completes iterations 2,3,4

Thread 1 is starting iteration 5
We hold these truths to be self-evident, that all men are created equal,
that they are endowed by their Creator with certain unalienable Rights,
that among these are Life, Liberty and the pursuit of Happiness.
Thread 1 is done with iteration 5

d) Replacing the above Dekker algorithm with the Peterson algorithm will ensure that no process enters the CS more than once when another process is waiting. It does so by setting the turn variable to the other process first, before setting its own flag and continuing on the the busy wait section.

Now, no matter where the process is interrupted, it can not be passed by a process that has already entered the CS. If it is interrupted after the first line (setting turn = j), process j can enter the CS once, but upon its return the second time, will find that turn = j, so it must busy wait for the first process to complete and set turn to j.

```
// Entry protocol for Q1d
turn = j;
flag[id] = true;
while (flag[j] && turn == j) {};

// Critical Section goes here
// Exit protocol
flag[id] = false;
```

output using the above entry/exit protocols:
Thread 0 is starting iteration 1
We hold these truths to be self-evident, that all men are created equal,
that they are endowed by their Creator with certain unalienable Rights,
that among these are Life, Liberty and the pursuit of Happiness.
Thread 0 is done with iteration 1
Thread 1 is starting iteration 1
We hold these truths to be self-evident, that all men are created equal,
that they are endowed by their Creator with certain unalienable Rights,
that among these are Life, Liberty and the pursuit of Happiness.
Thread 1 is done with iteration 1
Thread 0 is starting iteration 2
We hold these truths to be self-evident, that all men are created equal,
that they are endowed by their Creator with certain unalienable Rights,
that among these are Life, Liberty and the pursuit of Happiness.
Thread 0 is done with iteration 2
Thread 1 is starting iteration 2
We hold these truths to be self-evident, that all men are created equal,
that they are endowed by their Creator with certain unalienable Rights,
that among these are Life, Liberty and the pursuit of Happiness.
Thread 1 is done with iteration 2
Thread 0 is starting iteration 3
We hold these truths to be self-evident, that all men are created equal,
that they are endowed by their Creator with certain unalienable Rights,

that among these are Life, Liberty and the pursuit of Happiness.
Thread 0 is done with iteration 3
Thread 1 is starting iteration 3
We hold these truths to be self-evident, that all men are created equal,
that they are endowed by their Creator with certain unalienable Rights,
that among these are Life, Liberty and the pursuit of Happiness.
Thread 1 is done with iteration 3
Thread 0 is starting iteration 4
We hold these truths to be self-evident, that all men are created equal,
that they are endowed by their Creator with certain unalienable Rights,
that among these are Life, Liberty and the pursuit of Happiness.
Thread 0 is done with iteration 4
Thread 1 is starting iteration 4
We hold these truths to be self-evident, that all men are created equal,
that they are endowed by their Creator with certain unalienable Rights,
that among these are Life, Liberty and the pursuit of Happiness.
Thread 1 is done with iteration 4
Thread 0 is starting iteration 5
We hold these truths to be self-evident, that all men are created equal,
that they are endowed by their Creator with certain unalienable Rights,
that among these are Life, Liberty and the pursuit of Happiness.
Thread 0 is done with iteration 5
Thread 1 is starting iteration 5
We hold these truths to be self-evident, that all men are created equal,
that they are endowed by their Creator with certain unalienable Rights,
that among these are Life, Liberty and the pursuit of Happiness.
Thread 1 is done with iteration 5

2) Yes, this implementation of the Bakers algorithm will work. Since the first line of the entry protocol
sets the ticket for process i to 1, it puts this process at the highest priority. if interrupted at any point
when choosing the max ticket, other processes will still have to busy wait until it completes. This way a
process will always be able to store its number without being passed by another process. This last loop
ensures that requests are taken in number order (lower number = higher priority), and in the case of a
tie, the process that was created first is served first.

```java
// Entry protocol for Q2
ticket[id]=1;

// Find max ticket
int maximum = ticket[0];
for (int i=0; i<ticket.length; i++) {
     if (ticket[i] > maximum) {
          maximum = ticket[i];    // new maximum
     }
}
ticket[id] = maximum + 1;

for(int k=0; k<N; k++){
while(ticket[k]!=0 && ((ticket[k] < ticket[id]) ||
     ((ticket[k]==ticket[id]) && (k < id)) ) ){};
}
// Exit protocol for question 2
ticket[id] = 0;
```

output using the above entry/exit protocols (for 4 threads):

Thread 0 is starting iteration 1
We hold these truths to be self-evident, that all men are created equal,
that they are endowed by their Creator with certain unalienable Rights,
that among these are Life, Liberty and the pursuit of Happiness.
Thread 0 is done with iteration 1
Thread 3 is starting iteration 1
We hold these truths to be self-evident, that all men are created equal,
that they are endowed by their Creator with certain unalienable Rights,
that among these are Life, Liberty and the pursuit of Happiness.
Thread 3 is done with iteration 1
Thread 2 is starting iteration 1
We hold these truths to be self-evident, that all men are created equal,
that they are endowed by their Creator with certain unalienable Rights,
that among these are Life, Liberty and the pursuit of Happiness.
Thread 2 is done with iteration 1
Thread 1 is starting iteration 1
We hold these truths to be self-evident, that all men are created equal,
that they are endowed by their Creator with certain unalienable Rights,
that among these are Life, Liberty and the pursuit of Happiness.
Thread 1 is done with iteration 1
Thread 0 is starting iteration 2
We hold these truths to be self-evident, that all men are created equal,
that they are endowed by their Creator with certain unalienable Rights,
that among these are Life, Liberty and the pursuit of Happiness.
Thread 0 is done with iteration 2
Thread 3 is starting iteration 2
We hold these truths to be self-evident, that all men are created equal,
that they are endowed by their Creator with certain unalienable Rights,
that among these are Life, Liberty and the pursuit of Happiness.
Thread 3 is done with iteration 2
Thread 2 is starting iteration 2
We hold these truths to be self-evident, that all men are created equal,
that they are endowed by their Creator with certain unalienable Rights,
that among these are Life, Liberty and the pursuit of Happiness.
Thread 2 is done with iteration 2
Thread 1 is starting iteration 2
We hold these truths to be self-evident, that all men are created equal,
that they are endowed by their Creator with certain unalienable Rights,
that among these are Life, Liberty and the pursuit of Happiness.
Thread 1 is done with iteration 2
Thread 0 is starting iteration 3
We hold these truths to be self-evident, that all men are created equal,
that they are endowed by their Creator with certain unalienable Rights,
that among these are Life, Liberty and the pursuit of Happiness.
Thread 0 is done with iteration 3
Thread 3 is starting iteration 3
We hold these truths to be self-evident, that all men are created equal,
that they are endowed by their Creator with certain unalienable Rights,
that among these are Life, Liberty and the pursuit of Happiness.
Thread 3 is done with iteration 3
Thread 2 is starting iteration 3
We hold these truths to be self-evident, that all men are created equal,
that they are endowed by their Creator with certain unalienable Rights,
that among these are Life, Liberty and the pursuit of Happiness.
Thread 2 is done with iteration 3
Thread 1 is starting iteration 3
We hold these truths to be self-evident, that all men are created equal,

that they are endowed by their Creator with certain unalienable Rights,
that among these are Life, Liberty and the pursuit of Happiness.
Thread 1 is done with iteration 3
Thread 0 is starting iteration 4
We hold these truths to be self-evident, that all men are created equal,
that they are endowed by their Creator with certain unalienable Rights,
that among these are Life, Liberty and the pursuit of Happiness.
Thread 0 is done with iteration 4
Thread 3 is starting iteration 4
We hold these truths to be self-evident, that all men are created equal,
that they are endowed by their Creator with certain unalienable Rights,
that among these are Life, Liberty and the pursuit of Happiness.
Thread 3 is done with iteration 4
Thread 2 is starting iteration 4
We hold these truths to be self-evident, that all men are created equal,
that they are endowed by their Creator with certain unalienable Rights,
that among these are Life, Liberty and the pursuit of Happiness.
Thread 2 is done with iteration 4
Thread 1 is starting iteration 4
We hold these truths to be self-evident, that all men are created equal,
that they are endowed by their Creator with certain unalienable Rights,
that among these are Life, Liberty and the pursuit of Happiness.
Thread 1 is done with iteration 4
Thread 0 is starting iteration 5
We hold these truths to be self-evident, that all men are created equal,
that they are endowed by their Creator with certain unalienable Rights,
that among these are Life, Liberty and the pursuit of Happiness.
Thread 0 is done with iteration 5
Thread 3 is starting iteration 5
We hold these truths to be self-evident, that all men are created equal,
that they are endowed by their Creator with certain unalienable Rights,
that among these are Life, Liberty and the pursuit of Happiness.
Thread 3 is done with iteration 5
Thread 2 is starting iteration 5
We hold these truths to be self-evident, that all men are created equal,
that they are endowed by their Creator with certain unalienable Rights,
that among these are Life, Liberty and the pursuit of Happiness.
Thread 2 is done with iteration 5
Thread 1 is starting iteration 5
We hold these truths to be self-evident, that all men are created equal,
that they are endowed by their Creator with certain unalienable Rights,
that among these are Life, Liberty and the pursuit of Happiness.
Thread 1 is done with iteration 5

3) After running 10 test simulations (each with 2 process running simultaneously) we see that each request to the CS results in the busy-wait loop executing approximately 8,770,367 times.