C. [8pts] Answer questions about the results of the following code excerpt.

```java
int[] a = { 4, 2, 8, 6, 5, 3, 7, 1 };  
for (int i = 1; i < a.length; i++) {  
    for (int j = i; j > 0; j--) {  
        if (a[j] < a[j-1]) { // COMPARISON  
            int temp = a[j-1];  
            a[j-1] = a[j];  
            a[j] = temp;  
        }  
    }  
    for (int k = 0; k < a.length; k++)  
        System.out.print(a[k] + " ");  
    System.out.println();  
}
```

I. [4pts] What is the output of the following excerpt?

II. [4pts] Estimate how many times the comparison (a[j] < a[j-1]) is executed if the array has N elements. Your answer should be in terms of Big-Oh.

PROBLEM 2: *(Not Complex (20 points))*

Consider the method `calc` below in the class `Test1`. When the `main` method is executed the output is

127  
511  
511  
1023

You’ll be asked several questions about this method and other methods below.

```java
public class Test1 {  
    public int calc(int n) {  
        int sum = 0;  
        int val = 1;  
        while (val <= n) {  
            sum += val;  
            val *= 2;  
        }  
        return sum;  
    }  
    public static void main(String[] args) {  
        Test1 t = new Test1();  
        System.out.println(t.calc(100));  
        System.out.println(t.calc(256));  
        System.out.println(t.calc(511));  
    }
```
System.out.println(t.calc(512));
}
}

A. [6pts] What is the value returned by each of the calls $\text{calc}(31)$, $\text{calc}(32)$, and $\text{calc}(33)$.

B. [3pts] What is the smallest value of $x$ such that $\text{calc}(x)$ returns 2047? Justify your answer briefly.

C. [3pts] In terms of $n$, what is the exact value returned by the call $\text{calc}(2^n)$, justify your answer briefly.

D. [4pts] What is the runtime complexity of the call $\text{calc}(n)$, use big-Oh and justify your answer.

E. [4pts] What is the value of the expression $\text{calc}(\text{calc}(256))$? In terms of $n$, what value is the expression $\text{calc}(\text{calc}(2^n))$ – base your answer to the latter question on what you wrote for Part C?
PROBLEM 3:  (*TriPyramid (20 points)*)

The picture below shows a four-rowed, two-dimensional pyramid constructed of triangles – this will be called a *4-pyramid* in this problem because it has four rows. The top triangle is number one, then the triangles are numbered left-to-right in a row and top-to-bottom as shown. In the fourth row there are seven triangles; in general in the $N^{th}$ row there are $2N - 1$ triangles. In answering questions below assume we’re discussing an $N$-pyramid with $N$ rows for a large value of $N$.

**Part A (2 points)**
What is the *exact* value or number of the right-most triangle in the seventh row?

**Part B (2 points)**
What is the *exact* value of the right-most triangle in the 40$^{th}$ row?

**Part C (2 points)**
What is the *exact* value of the left-most triangle in the 61$^{st}$ row?

**Part D (2 points)**
Using big-Oh what is the number of triangles in the bottom row of a pyramid with $N$ rows. Justify your answer.

**Part E (2 points)**
Using big-Oh what is the number of triangles in the bottom row of a pyramid with $N^2$ total triangles. Justify your answer.

**Part F (2 points)**
Using big-Oh what is the number of triangles in the bottom row of a pyramid with $N^4$ total triangles. Justify your answer.
Part G (8 points)

The diagram below shows four 3-pyramids combined to make an 6-pyramid. Assume there is a function or method combine that takes an $N$-pyramid as a parameter and returns a new pyramid created by combining four $N$-pyramids as shown. For example, the pyramid shown below would be returned by the call combine(3).

![Diagram of combined pyramids](image)

G.1 (2 points)
What is the big-Oh number of triangles in the bottom row of the pyramid returned by the call combine($N$). Justify your answer.

G.2 (2 points)
What is the big-Oh value of the rightmost pyramid in the bottom row (the triangle with the largest number) in the pyramid returned by the call combine(combine($N$)). Justify your answer.

G.3 (4 points)

Consider the pseudo-code below for a sequence of calls to create a pyramid. For example, when $N = 2$ the initial pyramid $p$ is constructed before the loop with two rows and three triangles in the bottom row; the loop then executes twice. The first time through the loop results in $p$ having four rows. The second time through the loop results in $p$ having eight rows (with 15 triangles in the bottom row and the value printed is 64).

```java
Pyramid p = new Pyramid(N); // create pyramid with N rows
int size = p.rows(); // set size to N
for(int k=0; k < size; k++){
    p = combine(p);
}
System.out.println("biggest number is " + p.lastPyramid());
```

If the value of $N = 10$ so that the initial pyramid has 10 rows in which the last pyramid is numbered 100 what is the value printed by the code above? Justify your answer. Your answer should be exact, but can be expressed using exponentiation and multiplication, e.g., $3^2 \times 100^2$ is acceptable as an answer.