Question 1:

1. With single layer loop, even the worst case(vector is sorted) takes N iterations, so the time complexity is O(N).
2. Since the bubble sort is nested loop structure, and the range of both of the loops are depending on the size of the input. The first loop iterates n times and the second loop as well, so the time complexity will always be O(N^2).
3. If a list has N elements, the outer loop executes N - 1 times. For each of those N - 1 outer loop executions, the inner loop executes an average of N/2 times. So, the total number of comparisons is proportional to (N-1)(N/2), or O(N^2).

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|  | Best Time complexity | Worst Time complexity |
| Heapsort | O(N\*log(N)) | O(N\*log(N)) |
| Merge sort | O(N\*log(N)) | O(N\*log(N)) |
| Hybrid sort | O(N\*log(N)) | O(n^2) |
| Quick sort | O(N\*log(N)) | O(n^2) |

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| --- | --- | --- | --- | --- | --- |
| Run time when the data size is: | 1000 | 10000 | 100000 | 1000000 | Color on chart |
| Heap sort | 0.0002132 | 0.002784 | 0.0374027 | 0.526133 | Blue |
| Merge sort | 0.0002306 | 0.0029463 | 0.0387603 | 0.525495 | Orange |
| Hybrid sort | 0.0004534 | 0.0034777 | 0.0425107 | 0.529343 | grey |
| Quick sort | 0.0001861 | 0.0016555 | 0.0209486 | 0.236595 | Yellow |

Question 2:

Part B:

Pdf is uploaded together, please check PA4-1.pdf.

Part C:

The first for loop to build the min heap runs n times, thus it’s O(n).

The second for loop to extract min tuns k-1 times thus it’s O(k).

So the time complexity of this algorithm is O(kn).