1. What is the branching factor b in this state space?

up down left right -> 4

2. How many distinct states are there at depth k (for k larger than 0).

When K=1 , I can go 4 node.  
When k=2 , I can go 8 node

depth k -> 4k distinct state.

3. What is the maximum number of nodes expanded by breadth-first tree search?

1 + 42 + 43 + .... + 4 k = (4k+1 -1) / 3

4. What is the maximum number of nodes expanded by breadth-first graph search?

1 + 5 + 9 + 13 + ... + 1+ 4k = 1 + 2k(k +1)

5. Is h = |u - x| + |v - y| an admissible heuristic for a state at (u,v)? Explain.

Manhattan distance is the shortest path to the goal. In this problem, we can only go up, down, left, and right.

For example, if we assume one move cost is 1, if we move right and right twice, the cost is 2, and the Manhattan distance is also 2, so we did not overestimate. If we moved right and up, the cost is 2, and the Manhattan distance is √2, which is the distance of the diagonal connecting the two points, so it is admissible.

6. How many nodes are expanded by A\* graph search using h?

A\*, which uses heuristics, selects the optimal path as the most optimal path. Therefore, the expansion node is expanded in the same way as breadth-first graph search.

1 + 5 + 9 + 13 + ... + 1+ 4k = 1 + 2k(k +1)

7. Does h remain admissible if some links are removed?

The heuristic is based on the Manhattan distance, which is the minimum distance between two points in the grid. Removing a link may increase the actual path cost, but it does not decrease it. The heuristic is admissible because it does not overestimate the actual cost.

8. Does h remain admissible if some links are added between nonadjacent states?

It depends. If the additional links create shortcuts, then h may overestimate the true cost, breaking admissibility.