1.

```
import sys
import time
'''
Project created on Oct 21, 2017
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'''
'''The program should perform better than nklogn + nklogk'''


class Main():

   def __init__(self, file):
      self.file = file

   #tuples of a list, for every word in original document make a word into a tuple,
   #which includes a sorted_word and a original word. e.g.word ---> (dorw, word)

   def make_tuple(self, file, list):
      num_of_words = 0                              #How many words in the original file
      sort_time = time.time()
      for word in open(sys.argv[int(file_index)], 'r'):       #Go through the list, O(n)
         word = word.strip('\n')                    #get rid of \n at the end of each word, O(1)
         sorted_word = SortWord(word).quick_sort(word)      #sort each word using quick_sort()
         #sorted_word = Mergesort(word).merge_sort(word)     ###Mergesort() is slower than Quick_sort() in this case###
                                                  ###Mergesort() uses 3.6s, but Quick_sort() uses 1.5s###
                                                  #So, the Quick_sort() should be O(klog(k)) in this case
         list.append((sorted_word, word))                  #append tuples, each tuple contains (index of the original table,
sorted_word, word), O(1)
         num_of_words += 1                              #O(1)
      print('The number of words:', num_of_words)
      return self.sort(list)

   #When test_word has the same word with sorted word in next tuple, then append original word to list
   #if not, replace the next_word with sorted word in next_tuple, then move the original word into the list

   def sort(self, list):
      sort = Mergesort(list)
      sorted_word = sort.merge_sort(list)                  #Using Merge_sort to sort the whole list, O(nklog(n))
      #sorted_word = sorted(list, key = itemgetter(1))       #built-in sort method
      test_word = sorted_word[0][0]                        #Take the sorted_word from first tuple
      final_list = [[]]                              #the list_of_list will be returned
      index = 0
      for elem in sorted_word:                            #O(n)
         if test_word != elem[0]:                         #different word with test_word
            test_word = elem[0]                          #replace the test_word
            final_list.append([elem[1]])
            index += 1
         else:
            final_list[index].append(elem[1])            #same sorted_word but different original word
      return final_list                               #The final output is list_of_list. e.g.[['abc', 'cab'], ['igkl'], ['defgh', 'hgfed']]


class SortWord():

   def __init__(self, word):
      self.word = word
```

```
    #the worst case of quick_sort is O(n^2), however, it does not really affect the run time of this program,
    #because the len(words) are not large. Sorting the same amount of word use Mergesort() will spend more time at this point.

    def quick_sort(self, word):
        if word == '':
            return ''
        pivot = word[0]
        l, r = self.quick_sort_helper(word, pivot)
        left = self.quick_sort(''.join(l))         #starts with None, add all of chars that smaller than the pivot.
        right = self.quick_sort(''.join(r))        #starts with None, add all of chars that larger than the pivot.
        return left + pivot + right

    def quick_sort_helper(self, word, pivot):
        partition_left = [elem for elem in word[1::] if elem < pivot]   #move all of chars that smaller than pivot in the word to the
left.
        partition_right = [elem for elem in word[1::] if elem >= pivot]   #move all of chars in word to the right.
        return partition_left, partition_right


class Mergesort():

    def __init__(self, list):
        self.list = list

    #It sorts the whole list of words based on sorted words
    #e.g. [('dgo', 'dog'), ('abc', 'cba)] ---> [('abc', 'cba), ('dgo', 'dog')]

    def merge_sort(self, list):                              #which accepts a tuple of list [(sorted_word, word)]
        if len(list) < 2:                                    #when the len(list) < 2, return the list to last recurision
            return list
        middle = len(list) // 2                              #get the middle index of list. get lower index when the len(list) is even
        left_list = self.merge_sort(list[:middle])           #merge_sort() the left_list of a list
        right_list = self.merge_sort(list[middle:])          #merge_sort() the right_list of a list
        return self.merge_sort_helper(left_list, right_list)

    #Combine two lists into a single list,
    #First it compares the length of list. If the length is same, then compares the words based on the words themselves
    #e.g. 'abc' < 'abcd'; 'abc' < 'abd'
    #append the smaller one into the result[]

    def merge_sort_helper(self, left, right):
        i, j = 0, 0
        result = []
        while(len(result) < len(left) + len(right)):
            if i != len(left) and j != len(right) and len(left[i][0]) < len(right[j][0]):
                result.append(left[i])
                i += 1
            elif i != len(left) and j != len(right) and len(left[i][0]) > len(right[j][0]):
                result.append(right[j])
                j += 1
            elif i != len(left) and j != len(right) and left[i][0] == right[j][0]:
                result.append(left[i])
                result.append(right[j])
                i += 1
                j += 1
            elif i != len(left) and j != len(right) and left[i][0] < right[j][0]:
                result.append(left[i])
                i += 1
        elif i != len(left) and j != len(right) and left[i][0] > right[j][0]:
            result.append(right[j])
            j += 1
        elif i == len(left) or j == len(right):
            result.extend(left[i:] or right[j:])
    return result




if __name__ == '__main__':
    sys.argv.append("dict1.txt")
    sys.argv.append("dict2.txt")
    sys.argv.append("dict3.txt")
    list = []
    file_index = input('Please enter the file name (1/2) that you want to use :')
    main = Main(sys.argv[int(file_index)])
    while True:
        number = 0
        if 0 < int(file_index) < 4:
            print('correct number')
            start = time.time()
            list_of_list = main.make_tuple(sys.argv[int(file_index)], list)
            print("time", time.time() - start)
            f = open("anagram" + file_index+ ".txt", "w+")
            for elem in list_of_list:
                f.write("%s\n" % elem)
                if len(elem) >= 5:
                    number += 1
                    print(number, '.', elem)
            f.close()
            print(len(list_of_list))

            print("To grader: there is a blank row at the end of each file, I deleted that, so the number should be less 1 than 
original file")
            break
        else:
            print('incorrect number, please run again')
            sys.exit()
```

2.

Example: {abc, defgh, igkl, m, n, op, q, rstuvwxyz, cab, hgfed}

Step1: Turn the input file in to list, O(n)

[abc, defgh, igkl, m, n, op, q, rstuvwxyz, cab, hgfed]

Step2: Using quick sort to sort each word and bind them into a tuple of list.O(nklogk)

[('abc', 'abc'), ('defgh', 'defgh'), ('gikl', 'igkl'), ('m', 'm'), ('n', 'n'), ('op', 'op'), ('q', 'q'), ('rstuvwxyz', 'rstuvwxyz'), ('abc', 'cab'), ('defgh', 'hgfed')]

Step3: Based on the length and order of words, sort them as below.O(nlogn)

[('m', 'm'), ('n', 'n'), ('q', 'q'), ('op', 'op'), ('abc', 'abc'), ('abc', 'cab'), ('gikl', 'igkl'), ('defgh', 'defgh'), ('defgh', 'hgfed'), ('rstuvwxyz', 'rstuvwxyz')]

Step4: Using a test_word to check if next word has the same key, if the key is same, then append the original word to the end of the last element of final_list. If not, append a new list to final_list and update the test_word.O(n)
Finally, the program will give an output as below.

```
[['m'], ['n'], ['q'], ['op'], ['abc', 'cab'], ['igkl'], ['defgh', 'hgfed'], ['rstuvwxyz']]
```

Total: nklogk + nlogn+n

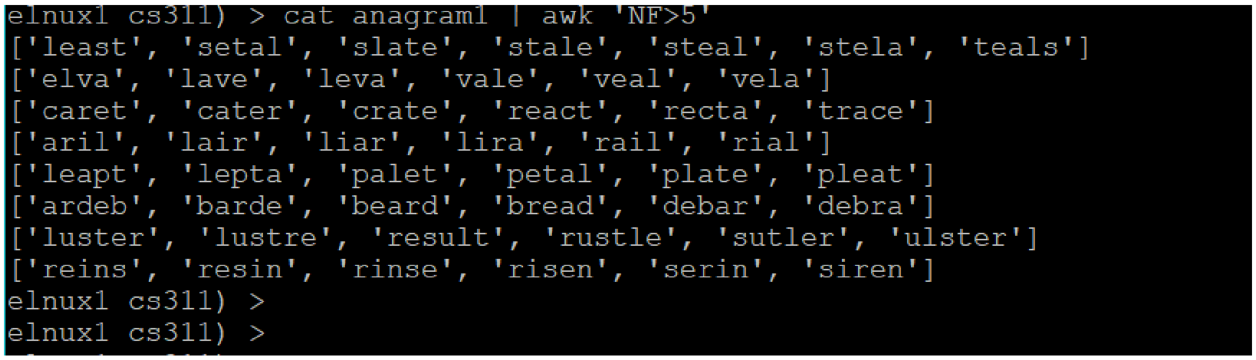
Observation of dict1:
Average time: 2.464
Time spent on each word: 0.00003428
Time spent on sorting words: 1.0392
Time spent on sorting single word: 0.00001446
Time spent on sorting whole list: 1.3474
Time spent on sorting whole list for each word: 0.00001874

Observation of dict2:
Average time: 220.344
Time spent on each word: 0.0006869
Time spent on sorting words: 66.590
Time spent on sorting single word: 0.000207
Time spent on sorting whole list: 143.842
Time spent on sorting whole list for each word: 0.000448

3.When I type `time a.out <dict1 >anagram1` in the console, it says a.out command not found. Please do it yourself.

Windows

4.
dict1: 67605
dict2: 320750



```
elnux1 cs311) > cat anagram1 | awk 'NF>5'
['least', 'setal', 'slate', 'stale', 'steal', 'stela', 'teals']
['elva', 'lave', 'leva', 'vale', 'veal', 'vela']
['caret', 'cater', 'crate', 'react', 'recta', 'trace']
['aril', 'lair', 'liar', 'lira', 'rail', 'rial']
['leapt', 'lepta', 'palet', 'petal', 'plate', 'pleat']
['ardeb', 'barde', 'beard', 'bread', 'debar', 'debra']
['luster', 'lustre', 'result', 'rustle', 'sutler', 'ulster']
['reins', 'resin', 'rinse', 'risen', 'serin', 'siren']
elnux1 cs311) >
elnux1 cs311) >
```

PS: I know the run time is not fast enough and the program is not performing good as well. However, I think that's enough fast enough for future if some people want to use this algorithm for their own purpose.