Part 1: String Basics (Definition & Moderate)

Q1. [Definition] What is the time complexity to access a character at a specific index in a Java String?
A. O(n)
B. O(log n)
C. O(1)
D. O(n log n)
Answer: C
Explanation: Java String is backed by a character array, allowing O(1) access.

Q2. [Definition] Which of the following is immutable in Java?
A. StringBuilder
B. StringBuffer
C. String
D. char[]
Answer: C
Explanation: Java String objects are immutable, i.e., cannot be changed once created.

Q3. [Definition] Which method is used to compare two strings ignoring case in Java?
A. equals()
B. compareToIgnoreCase()
C. equalsIgnoreCase()
D. contains()
Answer: C
Explanation: equalsIgnoreCase() compares strings without considering case.

Q4. [Moderate] What is the output of the following code?
```
String s = "hello";
System.out.println(s.substring(1, 3));
```
A. "he"
B. "ell"
C. "el"
D. "lo"
Answer: C
Explanation: substring(1, 3) returns characters from index 1 to 2 → "el".

Q5. [Moderate] Which method should be used to reverse a string in Java efficiently?
A. String.reverse()
B. StringBuffer.reverse()
C. Collections.reverse()
D. Arrays.reverse()
Answer: B
Explanation: StringBuffer and StringBuilder offer efficient reverse operations.

Q6. [Moderate] What will be the result of "hello" + 5 + 2?
A. "hello7"
B. "hello52"
C. Compilation Error
D. "hello"

Answer: B
Explanation: String concatenation happens left to right → "hello" + 5 → "hello5" → "hello5" + 2 → "hello52".

Q7. [Moderate] Which of the following is best to use for frequent string modifications?
A. String
B. StringBuilder
C. StringBuffer
D. char[]
Answer: B
Explanation: StringBuilder is non-thread-safe but faster for frequent string operations.

◆ **Part 2: Hashing in Strings**

Q8. [Definition] What is the use of a hash map in string problems?
A. Sorting
B. Counting characters or substrings
C. Reversing a string
D. String formatting
Answer: B
Explanation: Hash maps efficiently store frequencies and mappings for string manipulation.

Q9. [Moderate] What is the output of the following code?

```
String s = "abcabc";
Map<Character, Integer> freq = new HashMap<>();
for (char c : s.toCharArray()) {
    freq.put(c, freq.getOrDefault(c, 0) + 1);
}
System.out.println(freq.get('a'));
```

A. 3
B. 2
C. 1
D. 0
Answer: B
Explanation: The letter 'a' occurs twice in the string "abcabc".

Q10. [Definition] What is the time complexity of inserting a character in a HashMap in Java?
A. O(1) on average
B. O(log n)
C. O(n)
D. O(n log n)
Answer: A
Explanation: HashMap provides average-case O(1) time for put/get operations.
Q11. [Moderate] What would a HashSet be used for in string problems?
A. Counting characters
B. Storing all characters uniquely
C. Finding duplicates
D. B and C

Answer: D
Explanation: HashSet helps in uniqueness and duplicate detection.

Q12. [Difficult] Given two strings, determine if they are anagrams. Which data structure is best suited for this?
A. ArrayList
B. Stack
C. HashMap or frequency array
D. TreeMap
Answer: C
Explanation: Anagrams are verified by comparing character frequencies using HashMap or arrays.

◆ **Part 3: Frequency Array**

Q13. [Definition] How many indices are needed to store the frequency of lowercase English letters using an array?
A. 52
B. 128
C. 26
D. 256
Answer: C
Explanation: Lowercase letters range from 'a' to 'z' — 26 characters.

Q14. [Moderate] What is the output of this code for string s = "banana"?
java
CopyEdit
```
int[] freq = new int[26];
for (char c : s.toCharArray()) {
    freq[c - 'a']++;
}
System.out.println(freq['a' - 'a']);
```
A. 2
B. 3
C. 1
D. 0
Answer: B
Explanation: 'a' occurs 3 times in "banana".

Q15. [Moderate] What is the benefit of using a frequency array over HashMap in some string problems?
A. Faster access due to fixed size
B. More memory efficient
C. Better for limited character sets
D. All of the above
Answer: D
Explanation: Frequency arrays are constant-time, compact, and ideal for small fixed sets like alphabets.

Q16. [Difficult] Two strings are given. How can you check if they are anagrams using frequency arrays?
A. Count and compare
B. Sort and compare

C. Recursively check
D. Use regex
Answer: A
Explanation: Counting characters and comparing frequency arrays is optimal for anagram checking.

Q17. [Moderate] What is the output of the code below?

```
String s = "teststring";
int[] freq = new int[26];
for (char c : s.toCharArray()) {
    freq[c - 'a']++;
}
System.out.println(freq['t' - 'a']);
```

A. 3
B. 2
C. 1
D. 4
Answer: A
Explanation: 't' appears three times in "teststring".

◆ **Part 4: Difficult / Scenario-Based**

Q18. [Difficult] You are given a string and asked to return the index of the first non-repeating character. What's the best approach?
A. Use two loops
B. Use HashMap to store counts, then linear scan
C. Sort and scan
D. Use a stack
Answer: B
Explanation: HashMap gives frequency; then a single pass finds the first with count 1.

Q19. [Difficult] Which problem is not efficiently solvable using frequency arrays?
A. Find first unique character
B. Check anagram
C. Substring pattern matching
D. Count vowels
Answer: C
Explanation: Pattern matching often needs hashing or KMP, not just frequency.

Q20. [Difficult] What's the best structure to use when characters can be any Unicode symbol?
A. Frequency array of size 26
B. Frequency array of size 256
C. HashMap<Character, Integer>
D. Bit array
Answer: C
Explanation: Unicode symbols vary widely; HashMap adapts to all key types.

Q21. [Moderate] Which code correctly initializes a frequency array for digits (0–9)?

int[] freq = new int[?];
A. 26
B. 10
C. 128
D. 256
Answer: B
Explanation: 10 digits (0 to 9) → array of size 10 is needed.

Q22. [Difficult] You want to check if one string is a permutation of another. Best logic?
A. Sort and compare
B. HashSet
C. Compare frequency arrays
D. Recursion
Answer: C
Explanation: If both strings have same length and frequency arrays, they're permutations.

Q23. [Difficult] Which of the following operations is not O(1) with frequency arrays?
A. Increment count
B. Set count
C. Search for min frequency
D. Access index
Answer: C
Explanation: Finding min in array takes O(n) time even if access is O(1).

Q24. [Difficult] Which scenario will lead to a HashMap being preferred over frequency arrays?
A. Checking character frequency for only lowercase
B. Validating 0–9 digits
C. Frequency of emojis in a string
D. Comparing two lowercase strings
Answer: C
Explanation: HashMaps support wide/unpredictable character sets like emojis or Unicode.

Q25. [Difficult] You want to find the longest substring without repeating characters. Which combination is best?
A. Brute force + nested loop
B. HashMap + Sliding Window
C. Frequency array
D. Sort and match
Answer: B
Explanation: Sliding window with a HashMap tracks characters and ensures max length efficiently.

Q26. [Definition] What is a palindrome?
A. A string with unique characters
B. A string that reads the same backward as forward
C. A string with repeating characters
D. A string with only vowels
Answer: B
Explanation: Palindromes are symmetrical around their center.

Q27. [Definition] Which of the following is a palindrome?
A. "hello"
B. "level"
C. "string"
D. "world"
Answer: B
Explanation: "level" reads the same forward and backward.

Q28. [Definition] What is the minimum length of a non-empty palindromic substring?
A. 0
B. 2
C. 1
D. Depends on string
Answer: C
Explanation: Any single character is a palindrome of length 1.

Q29. [Definition] What is the time complexity of checking if a string is a palindrome?
A. O(n log n)
B. O(1)
C. $O(n^2)$
D. O(n)
Answer: D
Explanation: Comparing first and last characters toward the center takes O(n) time.

Q30. [Definition] In total, how many palindromic substrings exist in "aaa"?
A. 3
B. 4
C. 6
D. 7
Answer: C
Explanation: Substrings: "a", "a", "a", "aa", "aa", "aaa" → 6 total palindromic substrings.

◆ **Part 2: Moderate-Level – Expand Around Center, Brute Force**

Q31. [Moderate] Which approach is most common to count all palindromic substrings efficiently?
A. Two Pointers
B. HashSet
C. Expand Around Center
D. Sorting
Answer: C
Explanation: Expanding from each center in a string is a widely used and optimal approach.

Q31. [Moderate] How many centers exist for palindromic substring expansion in a string of length n?
A. n
B. 2n
C. n^2
D. n/2

Answer: B
Explanation: Each character and the gap between characters can be centers → 2n - 1 total centers.

Q33. [Moderate] Which method finds all palindromic substrings in O(n²) time and O(1) space?
A. KMP Algorithm
B. Manacher's Algorithm
C. Expand Around Center
D. Trie
Answer: C
Explanation: Expand Around Center is simple and efficient with O(n²) time and O(1) space.

Q34. [Moderate] What is the output of this function when s = "aba"?

```
boolean isPalindrome(String s) {
   int i = 0, j = s.length() - 1;
   while (i < j) {
      if (s.charAt(i++) != s.charAt(j--)) return false;
   }
   return true;
}
```

A. true
B. false
C. Compilation Error
D. Runtime Exception
Answer: A
Explanation: The string "aba" is a valid palindrome.

Q35. [Moderate] Which of the following substrings of "ababa" is the longest palindrome?
A. "aba"
B. "bab"
C. "ababa"
D. "aa"
Answer: C
Explanation: The entire string is symmetric and the longest palindromic substring.

◆ **Part 3: Advanced/Difficult (Dynamic Programming, Hashing, Manacher's)**

Q36. [Difficult] What is the time and space complexity of the DP approach to find the longest palindromic substring?
A. O(n²) time, O(n²) space
B. O(n log n), O(n)
C. O(n), O(n²)
D. O(n), O(1)
Answer: A
Explanation: 2D table dp[i][j] stores whether s[i..j] is a palindrome → O(n²) space and time.

Q37. [Difficult] Which condition is used in dynamic programming to check s[i..j] is a palindrome?
A. s[i] == s[j] && j - i <= 1
B. s[i] == s[j] && dp[i+1][j-1] == true

C. Both A and B
D. Only A
Answer: C
Explanation: For base case and recursive check, both are used.

Q38. [Difficult] Which of the following is the most time-efficient algorithm to find the longest palindromic substring?
A. Hashing
B. Manacher's Algorithm
C. Z-Algorithm
D. KMP
Answer: B
Explanation: Manacher's Algorithm finds the longest palindrome in O(n) time.

Q39. [Difficult] Which algorithm uses modified string with '#' delimiters to handle even-length palindromes?
A. Expand Around Center
B. DP Table
C. Manacher's Algorithm
D. Z-Algorithm
Answer: C
Explanation: Manacher's uses delimiters like '#' to unify even/odd palindrome processing.

Q40. [Difficult] What is the return value of longestPalindrome("abccbaabcd")?
A. "abccba"
B. "bccbaab"
C. "cc"
D. "abcd"
Answer: A
Explanation: "abccba" is the longest palindromic substring in the given string.

◆ **Part 4: Scenario-Based / Interview**

Q41. [Difficult] Given a string of length 100,000, which algorithm should you use to find the longest palindromic substring efficiently?
A. DP
B. Hashing
C. Manacher's Algorithm
D. Expand Around Center
Answer: C
Explanation: Only Manacher's achieves linear time suitable for large input sizes.

Q42. [Difficult] In an interview, you're asked to find the total number of palindromic substrings. What's your best strategy?
A. HashMap with index pairs
B. DP with 2D matrix
C. Expand Around Center
D. Recursion with memoization

Answer: C
Explanation: Expand Around Center counts all substrings efficiently with $O(n^2)$ time and $O(1)$ space.

Q43. [Difficult] What should be the base case in a DP table for palindromic substrings?
A. dp[i][i] = true
B. dp[i][i+1] = true if s[i] == s[i+1]
C. dp[i][j] = false
D. A and B
Answer: D
Explanation: Single character substrings are palindromes and so are even-length pairs if matched.

Q44. [Difficult] What is the value of count for s = "abcd" using palindromic substrings count function?
A. 4
B. 6
C. 2
D. 1
Answer: A
Explanation: All 4 single characters are individual palindromes.

Q45. [Difficult] What causes the DP method to fail for very large strings (e.g., 10^5)?
A. It is inaccurate
B. It consumes too much memory
C. Time complexity is too high
D. Both B and C
Answer: D
Explanation: $O(n^2)$ space and time make DP unusable for strings of size $>10^4$–10^5.

Part 1: Anagram Grouping

Q46. [Definition] Two strings are anagrams if:
A. They contain the same characters in different order
B. They are palindromes
C. One is substring of another
D. They start with the same letter
Answer: A
Explanation: Anagrams contain the same characters with same frequency.

Q47. [Definition] Which of the following pairs are anagrams?
A. "listen", "silent"
B. "night", "thing"
C. "loop", "pool"
D. All of the above
Answer: D
Explanation: All these word pairs have matching characters and frequencies.

Q48. [Moderate] What is the best way to check if two strings are anagrams (ignoring sort)?
A. Compare strings directly
B. Use HashMap/Array to count character frequency
C. Use recursion

D. Use Set
Answer: B
Explanation: Character count matching is optimal for anagram verification.

Q49. [Moderate] What is the time complexity of sorting strings to group anagrams?
A. O(n)
B. O(n log n)
C. O(m log m) per string
D. O(1)
Answer: C
Explanation: Each string of length m takes O(m log m) to sort.

Q50. [Moderate] Which data structure is most used in anagram grouping problems?
A. Queue
B. HashMap<String, List<String>>
C. Stack
D. TreeMap
Answer: B
Explanation: HashMap stores sorted/frequency signature as key and list of anagrams as value.

Q51. [Difficult] Which key is best for grouping anagrams using frequency counts (without sorting)?
A. Raw string
B. Sorted string
C. Frequency array converted to string (e.g. "2#0#1...")
D. HashCode
Answer: C
Explanation: Frequency signature string is a compact and hashable key for anagram grouping.

Q52. [Difficult] Why is sorting each string inefficient for large strings in anagram grouping?
A. Sorting is $O(n^2)$
B. Sorting changes original string
C. Sorting is slower than frequency count (O(m log m) vs O(m))
D. None
Answer: C
Explanation: Frequency array solution is linear (O(m)) while sorting is log-linear (O(m log m)).

Q53. [Difficult] What will be the output group for input: ["eat", "tea", "tan", "ate", "nat", "bat"]?
A. 6 groups
B. 3 groups: [["eat","tea","ate"], ["tan","nat"], ["bat"]]
C. 2 groups
D. All same group
Answer: B
Explanation: Grouping based on sorted or frequency-matching keys.

Q54. [Difficult] What is the worst-case time complexity for grouping n strings of length m using sorting?
A. O(n)
B. O(nm log m)
C. $O(n^2)$
D. O(n log n)

Answer: B
Explanation: Each string of length m takes O(m log m), for n strings → O(nm log m).

Q55. [Difficult] How can we reduce space usage in grouping anagrams without using extra list?
A. Use TreeMap
B. Sort in-place
C. Modify input array
D. You cannot avoid extra space
Answer: D
Explanation: Grouping always requires extra space to group/track elements.

◆ **Part 2: Sliding Window on Strings**

Q56. [Definition] Sliding window technique is used when:
A. We need to find repeating elements
B. We process substrings of fixed or variable length efficiently
C. We sort strings
D. We reverse substrings
Answer: B
Explanation: Sliding window helps scan over substrings with limited movement and memory.

Q57. [Definition] Which problem is best solved using sliding window technique?
A. Reverse a string
B. Count total anagrams of pattern in a string
C. Convert string to integer
D. Find all palindromes
Answer: B
Explanation: Fixed-size sliding window is ideal for pattern/anagram matching.

Q58. [Moderate] What is the window size for finding all anagrams of "abc" in a string s?
A. 1
B. 2
C. 3
D. Variable
Answer: C
Explanation: Anagrams must match the pattern's length.

Q59. [Moderate] How do you check if the current window is an anagram of pattern p?
A. Compare string hash
B. Compare frequency array of size 26
C. Sort window
D. Convert to set
Answer: B
Explanation: Character frequency arrays can be compared in O(1) time if size is fixed.

Q60. [Moderate] What is the time complexity of finding all anagrams of pattern p in string s using sliding window?
A. O(n × m)
B. O(n log m)

C. O(n + m)
D. O(n)
Answer: D
Explanation: Frequency array comparison and movement are done in linear time.

Q61. [Moderate] What is the output of this code for s = "cbaebabacd", p = "abc"?

// find start indices of anagrams of p in s
A. [0, 6]
B. [1, 2, 5]
C. [2, 4]
D. [1, 3, 5]
Answer: A
Explanation: "cba" at index 0 and "bac" at index 6 are valid anagrams.

Q62. [Difficult] Which algorithm uses two frequency arrays for matching pattern in sliding window problems?
A. KMP
B. Rabin-Karp
C. Anagram finder
D. LPS Matcher
Answer: C
Explanation: Two frequency arrays—one for pattern, one for window—are compared during the scan.

Q63. [Difficult] Which trick allows constant time frequency comparison when sliding the window?
A. Full sort every time
B. Hash comparison
C. Add 1 to entering char, subtract 1 from exiting char
D. Binary Search
Answer: C
Explanation: Update char counts incrementally to avoid re-scanning entire window.

Q67. [Difficult] What is the space complexity for sliding window anagram check on lowercase letters?
A. O(1)
B. O(n)
C. O(log n)
D. $O(n^2)$
Answer: A
Explanation: Frequency array of size 26 → constant space usage.

Q68. [Difficult] You want to find the minimum window substring that contains all characters of a target string. What technique is best?
A. Expand Around Center
B. Sliding Window + HashMap
C. Sorting
D. DP
Answer: B
Explanation: Variable size sliding window with character map tracks shortest valid substring.
Part 1: Manacher's Algorithm

Q69. [Definition] What is the primary use of Manacher's Algorithm?
A. String sorting
B. Finding longest palindromic substring in linear time
C. Finding anagrams
D. Pattern matching
Answer: B
Explanation: Manacher's efficiently finds the longest palindromic substring in O(n) time.

Q70. [Definition] What modification is made to the input string in Manacher's Algorithm?
A. Characters are reversed
B. Special characters like '#' are added between characters
C. String is sorted
D. Extra whitespace is trimmed
Answer: B
Explanation: Delimiters like # are added to handle even and odd-length palindromes uniformly.

Q73. [Definition] What is the time complexity of Manacher's Algorithm?
A. $O(n^2)$
B. O(n log n)
C. O(n)
D. O(1)
Answer: C
Explanation: Manacher's Algorithm runs in linear time.

Q74. [Moderate] Which of the following strings will become "^#a#b#a#$" in preprocessing?
A. "aba"
B. "abac"
C. "ab"
D. "abcba"
Answer: A
Explanation: "^" and "$" are boundaries, and '#' separates each character.

Q75. [Moderate] What role does the array P[i] play in Manacher's Algorithm?
A. Stores prefix sums
B. Stores lengths of palindromes centered at i
C. Stores hash values
D. Stores substring indexes
Answer: B
Explanation: P[i] indicates the radius of palindrome centered at position i.

Q76. [Moderate] What happens when the palindrome centered at i expands beyond the current right?
A. Update left and right
B. Terminate the loop
C. Re-initialize P[]
D. Skip to next odd index
Answer: A
Explanation: left and right are updated when a longer palindrome is found.

Q77. [Difficult] What is the length of the longest palindromic substring in "abcba"?
A. 3
B. 5
C. 4
D. 2
Answer: B
Explanation: The entire string is a palindrome.

Q78. [Difficult] Which optimization makes Manacher's linear?
A. Avoiding recomputation of palindrome lengths using mirrored indices
B. Using two pointers
C. Sorting characters
D. Brute force substring comparison
Answer: A
Explanation: Manacher's leverages symmetry by using previously computed results.

Q79. [Difficult] After preprocessing "racecar", how many characters are in the transformed string?
A. 13
B. 15
C. 9
D. 5
Answer: A
Explanation: "^#r#a#c#e#c#a#r#$" → 13 characters.

Q80. [Difficult] In Manacher's algorithm, what is returned as the final result?
A. Max value in array P[]
B. Index of center
C. P[], L[], and R[]
D. Count of odd palindromes
Answer: A
Explanation: The max value in P[] gives the radius of the longest palindromic substring.

◆ **Part 2: Z-Algorithm (Pattern Matching)**

Q81. [Definition] What is the Z-array in the Z-algorithm?
A. Stores hash values
B. Stores LPS values
C. Stores length of longest substring starting at i that matches the prefix
D. Stores frequency count
Answer: C
Explanation: Z[i] = longest substring starting at i which is also a prefix of the entire string.

Q82. [Definition] What is the time complexity of the Z-algorithm?
A. O(n log n)
B. O(n)
C. $O(n^2)$
D. O(1)
Answer: B
Explanation: Z-algorithm computes all Z-values in linear time using windowing.

Q83. [Moderate] What is the output Z-array for the string "aabxaabxcaabxaabxay"?
A. Problem-specific, depends on match lengths
B. All zeros
C. All n
D. All ones
Answer: A
Explanation: The Z-array is unique to each pattern and reflects its prefix structure.

Q84. [Moderate] How do you use Z-algorithm for pattern searching in string S with pattern P?
A. Build Z-array of P + $ + S
B. Build Z-array of S only
C. Build suffix array
D. Use Trie
Answer: A
Explanation: Concatenate P + "$" + S, then scan for Z[i] = P.length().

Q85. [Moderate] What is the purpose of the special separator character ($ or #) in pattern + text?
A. Remove whitespace
B. Separate pattern from text to avoid overlap
C. Improve time complexity
D. Add to prefix
Answer: B
Explanation: Prevents false Z-matches across pattern-text boundaries.

Q86. [Moderate] Which of the following can Z-algorithm solve efficiently?
A. Prefix queries
B. Substring pattern search
C. Repetition finding
D. All of the above
Answer: D
Explanation: Z-values can be reused to solve multiple string problems.

Q87. [Difficult] If Z[i] = pattern.length() in a Z-array for "P$S" → what does it mean?
A. Mismatch
B. Partial match
C. Full match of pattern starting at index i - (pattern.length() + 1) in S
D. Error
Answer: C
Explanation: That index in S marks the start of a complete pattern match.

Q88. [Difficult] In Z-algorithm, what does maintaining a [L, R] window help with?
A. Avoids recomputation
B. Speeds up hash comparison
C. Avoids overflow
D. Ensures string is reversed
Answer: A
Explanation: Reuse previous matches to extend current match without restarting.

Q89. [Difficult] When is Z-algorithm better than KMP for pattern matching?
A. When preprocessing is costly
B. When patterns repeat heavily
C. When all prefix matches are needed
D. Never
Answer: C
Explanation: Z-algorithm is excellent for multiple prefix or substring matches.

Q90. [Difficult] What happens if the pattern is equal to the entire string? Z[1] = ?
A. n - 1
B. n
C. 0
D. n/2
Answer: A
Explanation: Since Z[0] is always 0, Z[1] holds the length of the full match (n - 1).