Computer Science Contest #1415-04 Key

November 01, 2014

1)	A	21)	D
2)	C	22)	B
3)	A	23)	B
4)	D	24)	A
5)	C	25)	C
6)	C	26)	D
7)	A	27)	D
8)	A	28)	A
9)	D	29)	D
10)	D	30)	A
11)	C	31)	E
12)	D	32)	A
13)	C	33)	C
14)	A	34)	A
15)	D	35)	E
16)	E	36)	C
17)	B	37)	E
18)	D	38)	C
19)	C	39)	$A*B \oplus C$ (See explanations)
20)	B	40)	42

Note to Graders:

- All provided code segments are intended to be syntactically correct, unless otherwise stated (e.g. error is an answer). **Ignore any typographical errors**.
- Any necessary Standard Java 2 Packages are assumed to have been imported as needed.
- Assume any undefined (undeclared) variables have been defined as used.

Explanations:

1. ANS: A 11100110_2 - 11001000_2 = 230_{10} - 200_{10} = 30_{10} = 36_8 = $1E_{16}$ = 11110_2
2. ANS: C $7 * 3 / 10 + 5 = 7$
3. ANS: A The first operation performed in this expression is the multiplication of 2 and 1, followed by the subtraction of 4.3 and 2, followed by the concatenation to that result of the string and value 2.
4. ANS: D This single parameter substring starts at the character in position 4, the 'S', and takes the rest of the string, which is 15 characters long, resulting in "SchoolRocks15".
5. ANS: C The NOT reverses the false value of P AND Q, making that expression true. Since it only takes one true to cause OR to be true, NOT P is true, therefore the entire expression is true, regardless of the fact that q is false.
6. ANS: C The smaller of the two values -5 and -4 is -5.
7. ANS: A $9.7 - 10.3 = -0.6$
8. ANS: A Since `disc` comes before `disk`, the if is true and the output is `"disc mush disk"`
9. ANS: D The first value is the result of 73/2, which is 36, and the last value is the one that ends the loop, which is 4 (36/2 = 18, 18/2 = 9, 9/2 = 4)
10. ANS: D In this loop, the value of each element is used as an index value to output the value of the element in that position in the array. The element in position 7 is the value 6, followed by the 4 in position 3, the 2 in position 5, etc.
11. ANS: C Only choice C works. Choice B has the whitespace issue after the nextLine(), which will cause a runtime error with nextDouble(), nextInteger is not valid in Choice D, and nextChar is not valid in choice E.
12. ANS: D For loops can be constructed in this manner, although it is not common. The only thing that absolutely must be inside of the for loop structure is the middle section, the boolean check. The first part (the start) can be before the for loop, and the step can be inside the body of the loop. In this example, there is no start, but there are three expressions in the step section, which is also legal.
13. ANS: C The multiplicative operators go first (* / % - line 3), then the equality operators (== != - line 7), and finally the assignment operators (= += -= *= /= %= &= ^= |= <<= >>= >>>= - last line).
14. ANS: A Since the int primitive data type takes 32 bits of storage, and the first bit is the sign bit, 31 bits are actually used for the value, and since the first non-negative value is zero, the maximum positive value is 2^31-1, or 2147483647.
15. ANS: D Although it seems there should be 10 elements because of the size parameter given in the constructor, the list is still empty. The parameter only indicates an initial capacity, and does not automatically create ten objects or ten null locations in the array.
16. ANS: E The split pattern [aeiou]+ produces the six elements "F", "rst d", "y ", "f ", "t" and "mn.", which are in positions 0 through 5 of the resulting array. There is no position 6, therefore an error results from the attempted access of position 6.
17. ANS: B The order of operations in this expression is: --i4 first, which makes 3, then i3*i4 which makes 9, then that added to i1 which makes 10, then 2 << 10, which makes 2048.
18. ANS: D This is the classic insertion sort, where one by one, from the second element to the end of the list, the best place is found for each element. After the first iteration, the 2 was moved from position 1 to the front of the list, with no other changes. Next, the 3 was moved in front of the 4. On the third iteration, the 7 was already in the best place for it based on all the previous elements, so no change was made, therefore the order after the third iteration was: 2 3 4 7 5 8 1
19. ANS: C The insertion sort average Big O classification is O(N^2), characterized by the nested loop structure. The best case is O(N) when the list is already sorted, or only a few elements are out of order.
20. ANS: B This code essentially multiplies 14 X 13, which is 182.
21. ANS: D This is a simple matrix addition problem, where elements in corresponding locations from grid1 and grid2 are added and assigned to grid3, resulting in grid3 containing the elements `{{9,4,7},{5,8,12},{9,17,13},{10,13,17}}`
22. ANS: B The correct Java term for one class inheriting another is "extends". The term "implements" is for using interfaces. The term "inherits" is not a Java reserved word, and the term "imports" is for including Java packages.
23. ANS: B Since the object created is of class A, the output calls the class A method with the class A x value, which produces `"dog5"`
24. ANS: A Although the value of x in class B is changed to 6, calling the super's method do_ will still use the class A version of the variable x, not the B version, therefore the output is `cat5dog5`.
25. ANS: C Here is the sequence of events for this code: 4 and 9 are each added to the back of the list, followed by 9, also added to the back. 5 and 7 are added to the front and back, respectively, and then 5 is output (but not removed) by the element command. The 5 and 7 are both removed, leaving the list [4, 9, 5]. The peekFirst command outputs the 4, and then all three remaining elements are removed, leaving an empty list. The final peekFirst command returns null since the list is empty.

26. ANS: D   Using the sorted list as shown here, 0 1 1 2 3 3 5 5 6 7 8 9, it is clear that the value 6 is in position 8, and the first occurrence of 5 is in position 6. The 4 should be in position 6, but is not, which is indicated by the complement of 6, value -7, **(-(*insertion point*) - 1) .**

27. ANS: D

28. ANS: A   Here are the results of the Stack after each add sequence:
```
[G, O, _, E, A, G, L, E, S]//after the initial add loop
[G, O, _, E, A, G, L, E, !, S]//after the st.add(s.length()-1,'!');
[G, O, _, E, A, G, L, E, !, S, !]//after the st.push('!');
[G, O, _, E, A, G, L, E, !, S, !, !]//after the st.add('!');
[G, O, _, E, A, G, L, E, !, !, S, !, !]//after the st.add(s.length(),'!');
```
29. ANS: D   Even though the range limits of these methods vary, all of them will generate some random value from 0 to 10, inclusive.

30. ANS: A   In a Priority Queue, the elements are stored in a min heap, therefore simply outputting the heap will not appear in order, but removing each element from the top of the heap until the queue is empty WILL show the elements in natural order for that data type.

31. ANS: E   There are 16 different two-hop flights in this graph. There are 2 from Austin to Austin, AAA and ADA, 2 from Austin to Boston, ADB and ACB, 1 from Austin to Chicago, AAC, and 2 from Austin to Dallas, AAD, and ACD. The rest are: BCB, BCD, CDA, CDB, CBC, DAD, DBC, DAC, and DAA. You can discover all of these by looking carefully at the graph and tracing each flight, OR you can use matrix multiplication to solve it. That process is shown below.
```
     M                M               M^2
  A B C D          A B C D         A B C D
A 1 0 1 1        A 1 0 1 0       A 2 2 1 2   --> Total number of two-hop flights is
B 0 0 1 0   X    B 0 0 1 0   =   B 0 1 0 1       the sum of all the values in the
C 0 1 0 1        C 0 1 0 1       C 1 1 1 0       M^2 matrix:
D 1 1 0 0        D 1 1 0 0       D 1 0 2 1       2+2+1+2+0+1+0+1+1+1+1+0+1+0+2+1=16
```

32. ANS: A   The values of v in the loop are all the odds from 3 through 30, i.e., 3, 5, 7, 9, etc. The only odds that divide the value 50 evenly are 5 and 25, thus the returned value of c is 2.

33. ANS: C   This operation is the equivalent of integer dividing 125 by 8 (2^3), which is 15.

34. ANS: A   A TreeSet contains no duplicates, and stores the values in their natural ascending order. There are 9 different values in this list, 1-9, thus 9 1 9 represents the size of the list, the first element, and the last element.

35. ANS: E   The TreeSet `remove()` method has a guaranteed log N time process.

36. ANS: C   63 in 8-bit binary is 00111111. Applying the rule mentioned in the problem gives you 11000001, which is the binary equivalent of -63.

37. ANS: E   Since the - is directly in front of the 4 and 5, that must go inside parentheses to maintain the correct order of operations, then the * goes between the 3 and 2, with the + in the middle.

38. ANS: C   The signals A and B go into and AND gate, whose result feeds a NOR gate with the value C, whose signal then goes into an OR gate, which also receives the XOR result of NOT C and D.

39. ANS: $A*B\oplus C$ Here is the simplification sequence, with the Boolean laws that were applied:

$(\overline{\overline{\overline{A}+\overline{B}*\overline{C}}})+(A*(\overline{\overline{B}+\overline{C}}))$	
$A*B*\overline{C}+A*\overline{B}*C$	- DeMorgan Law and Double Negative laws
$A(B\overline{C}+\overline{B}C)$	- Factor out A
Answer: $A*B\oplus C$	- XOR simplification

Note: Both AND and XOR are commutative, so if either part of the expression is reversed, the answer is acceptable

40. ANS: **42**   This sequence is called the "Catalan Numbers". One application of the sequence is to find the number of ways to parenthesize an expression. Below is the recursive trace for the value 5.

Recursive Trace # 40

$$A(5) = A(4)A(0) + A(3)A(1) + A(2)A(2) + A(1)A(3) + A(0)A(4)$$
$$= 14 \cdot 1 + 5 \cdot 1 + 2 \cdot 2 + 1 \cdot 5 + 1 \cdot 14 = \boxed{42}$$

$$A(4) = A(3)A(0) + A(2)A(1) + A(1)A(2) + A(0)A(3) =$$
$$= 5 \cdot 1 + 2 \cdot 1 + 1 \cdot 2 + 1 \cdot 5 = \boxed{14}$$

$$A(3) = A(2)A(0) + A(1)A(1) + A(0)A(2) =$$
$$2 \cdot 1 + 1 \cdot 1 + 1 \cdot 2 = \boxed{5}$$

$$A(2) = A(1)A(0) + A(0)A(1) =$$
$$1 \cdot 1 + 1 \cdot 1 = 1 + 1 = \boxed{2}$$

$$A(1) = A(0)A(0) = 1 \cdot 1 = \boxed{1}$$

$$A(0) = \boxed{1}$$