A Story of Numbers: Thinking Puzzles

Standard difficulty · 20 questions · 40 marks · Time: 36 minutes

Name: _____ Date: _____ Score: ____ / 40

Show your working for Sections B and C. Answers are on the last page — try every question first!

Section A — Choose the correct answer — 8 × 1 = 8 marks

1. In base 2, the only digits used are:
(a) 0, 1 and 2 **(b)** 0 to 9 **(c)** 1 and 2 **(d)** 0 and 1

2. What is 235 in binary?
(a) 11101011 **(b)** 11101010 **(c)** 111010110 **(d)** 11010111

3. What is the binary number 1000110 in decimal?
(a) 71 **(b)** 49 **(c)** 69 **(d)** 70

4. With pipes of length 1, 3, 9, 27, 81 (two of each), how is 38 written in base 3?
(a) 1101 **(b)** 2011 **(c)** 1110 **(d)** 1102

5. What number is MMDCCXCVI?
(a) 2,786 **(b)** 2,816 **(c)** 2,796 **(d)** 2,806

6. How is 1044 written in Roman numerals?
(a) CMXLIV **(b)** MLIV **(c)** MXLIII **(d)** MXLIV

7. How many digits does 4,427 have when written in binary?
(a) 13 **(b)** 4 **(c)** 14 **(d)** 12

8. Blocks show 5, 29, 21, 23, 19. Only neighbouring blocks may be swapped. What is the fewest swaps that puts them in ascending order?
(a) 7 **(b)** 6 **(c)** 5 **(d)** 4

Section B — Short answer — 8 × 2 = 16 marks

9. Why can the digit 2 not appear in a binary number?

10. Binary pipes come in lengths 1, 2, 4, 8, 16, 32, 64 and 128 inches, one of each. Which pipes together measure exactly 113 inches? Write them from longest to shortest.

11. Write the base-3 number 11202 in decimal.

12. Find the next two numbers in the pattern: LIX, XLIX, XXXIX, …

13. Only neighbouring numbers may be swapped. What is the fewest swaps needed to arrange 26, 38, 36, 32, 8, 28 in ascending order?

14. Write 548 in base 5.

15. Add the binary numbers 111000 and 110101. Give the answer in binary.

16. (a) With binary pipes (1, 2, 4, 8, … one of each), how many pipes measure 907 inches? (b) With decimal pipes (1, 10 and 100 inches, up to nine of each), how many pipes are needed?

Section C — Word problems — 4 × 4 = 16 marks

17. Write 173 (a) in binary (b) in base 3 (c) in Roman numerals.

18. 4423 is a number in base 6. (a) What is it in decimal? (b) What is the next number, written in base 6? (c) What is the largest 4-digit base-6 number, in decimal?

19. The numbers 37, 31, 33, 34, 2, 49 are to be sorted by swapping neighbours. (a) What is the fewest swaps needed? (b) One pass compares each neighbouring pair from left to right and swaps it if it is out of order. Write the list after one pass. (c) How many swaps did that pass make?

20. A school gives every student a code. (a) How many different codes can be made with 5 binary digits? (b) What is the fewest binary digits that give 804 students different codes? (c) What is the fewest decimal digits that would do?

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Answer key

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Q	Answer	Working
1	**(d) 0 and 1**	—
2	**(a) 11101011**	235 = 128 + 64 + 32 + 8 + 2 + 1
3	**(d) 70**	64 + 4 + 2
4	**(d) 1102**	38 = 1 × 27 + 1 × 9 + 2 × 1
5	**(c) 2,796**	MMDCCXCVI: a smaller numeral before a larger one is subtracted
6	**(d) MXLIV**	1044 = MXLIV
7	**(a) 13**	4,096 ≤ 4,427 < 8,192
8	**(c) 5**	count the pairs that are out of order: 5
9	**In base 2 two of a place make one of the next place, so the digits are only 0 and 1.**	—
10	**64, 32, 16, 1**	113 in binary is 1110001
11	**128**	1 × 81 + 1 × 27 + 2 × 9 + 0 × 3 + 2 × 1
12	**XXIX, XIX**	59, 49, 39: subtract 10 → 29, 19
13	**10**	each swap of neighbours fixes exactly one out-of-order pair, so count those pairs
14	**4143**	548 = 4 × 125 + 1 × 25 + 4 × 5 + 3 × 1
15	**1101101**	56 + 53 = 109 = 1101101
16	**(a) 6; (b) 16**	907 = 1110001011 in binary (count the 1s); count the decimal digits' total: 9 + 0 + 7
17	**(a) 10101101; (b) 20102; (c) CLXXIII**	powers of 2 and of 3; 173 = CLXXIII
18	**(a) 1023; (b) 4424; (c) 1295**	4 × 216 + 4 × 36 + 2 × 6 + 3 × 1; 5555 = $6^4 - 1$
19	**(a) 7; (b) 31, 33, 34, 2, 37, 49; (c) 4**	count out-of-order pairs; in a pass the largest number moves to the end
20	**(a) 32; (b) 10; (c) 3**	2^5; $2^9 = 512 < 804 \le 2^{10} = 1024$; $10^3 \ge 804$

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