Boolean Logic

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. Which gate gives an output of 1 only when all its inputs are 1?
(a) NAND **(b)** XOR **(c)** OR **(d)** AND

2. A two-input gate gives these outputs for the inputs 00, 01, 10 and 11: 0, 1, 1, 1. Which gate is it?
(a) XOR gate **(b)** NOR gate **(c)** OR gate **(d)** NAND gate

3. In the truth table of NOT C AND (B OR NOT A), in how many of the 8 rows is the output 1?
(a) 5 **(b)** 3 **(c)** 4 **(d)** 2

4. By De Morgan's law, NOT (NOT X OR Y) is equal to:
(a) X OR NOT Y **(b)** X OR Y **(c)** X AND NOT Y **(d)** NOT X AND Y

5. For which of these inputs is R XOR (P OR Q) equal to 1?
(a) P = 0, Q = 1, R = 1 **(b)** P = 1, Q = 0, R = 1
(c) P = 1, Q = 1, R = 0 **(d)** P = 1, Q = 1, R = 1

6. X and Y go into an XOR gate; its output and Z go into a NOR gate. Which expression gives the final output?
(a) NOT ((X XOR Y) OR Z) **(b)** (X XOR Y) XOR Z
(c) X XOR NOT (Y OR Z) **(d)** NOT (X AND Y) XOR Z

7. X and Y go into a NOR gate; its output and Z go into a NAND gate. For how many of the 8 input combinations is the final output 1?
(a) 7 **(b)** 8 **(c)** 1 **(d)** 6

8. A NAND gate has 3 inputs. In how many of the 8 rows of its truth table is the output 1?
(a) 1 **(b)** 8 **(c)** 3 **(d)** 7

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

9. State both of De Morgan’s laws.

10. For A = 1 and B = 1, find (a) A NAND B (b) A OR B (c) A NOR B.

11. Write the output column of the truth table of NOT (NOT N XOR (N OR NOT M)) for the rows MN = 00, 01, 10, 11.

12. Use De Morgan's law to write NOT (X OR NOT Y) without a NOT in front of the brackets.

13. In how many of the 8 rows of the truth table is (P XOR NOT Q) OR R equal to 1?

14. A and B go into an AND gate; its output and C go into a NOR gate. What is the final output for (a) A = 0, B = 0, C = 1 (b) A = 1, B = 0, C = 0?

15. Two-input gates give these outputs for the inputs 00, 01, 10, 11. Name each gate: (a) 0, 1, 1, 1 (b) 0, 1, 1, 0

16. For A = 0 and B = 1, find (a) NOT (A AND B) (b) NOT A OR NOT B (c) NOT (A OR B) (d) NOT A AND NOT B.

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

17. Draw the symbols and write the truth tables of the AND, OR and NOT gates.

18. Make the truth table of Y OR (X XOR Z). Write its output column for the rows XYZ = 000, 001, 010, 011, 100, 101, 110, 111.

19. A and B go into an XOR gate; its output and C go into an OR gate. (a) Write the Boolean expression for the final output. (b) What is the output for A = 1, B = 1, C = 1? (c) For how many of the 8 input combinations is the output 1?

20. (a) Prove the De Morgan's law NOT (P OR Q) = NOT P AND NOT Q with a truth table: write both output columns for PQ = 00, 01, 10, 11. (b) Use De Morgan's law to simplify NOT (NOT P AND Q).

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Answer key

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Q	Answer	Working
1	**(d) AND**	—
2	**(c) OR gate**	OR: 0, 1, 1, 1
3	**(b) 3**	output column: 1, 0, 1, 0, 0, 0, 1, 0
4	**(c) X AND NOT Y**	NOT (P OR Q) = NOT P AND NOT Q, and NOT NOT P = P
5	**(c) P = 1, Q = 1, R = 0**	work out the expression for each row
6	**(a) NOT ((X XOR Y) OR Z)**	first gate: X XOR Y
7	**(a) 7**	output column: 1, 0, 1, 1, 1, 1, 1, 1
8	**(d) 7**	NAND is every row but one
9	**NOT (A AND B) = NOT A OR NOT B; NOT (A OR B) = NOT A AND NOT B.**	—
10	**(a) 0; (b) 1; (c) 0**	NAND: 1, 1, 1, 0; OR: 0, 1, 1, 1; NOR: 1, 0, 0, 0
11	**1, 0, 0, 0**	00 → 1; 01 → 0; 10 → 0; 11 → 0
12	**NOT (X OR NOT Y) = NOT X AND Y**	NOT changes OR to AND and is applied to each part; NOT NOT P = P
13	**6**	output column: 1, 1, 0, 1, 0, 1, 1, 1
14	**(a) 0; (b) 1**	output = NOT ((A AND B) OR C)
15	**(a) OR; (b) XOR**	—
16	**(a) 1; (b) 1; (c) 0; (d) 0**	(a) and (b) are always equal, and so are (c) and (d): De Morgan’s laws
17	**AND (D-shaped): 1 only for 11; OR (curved): 0 only for 00; NOT (triangle with a circle): 0 → 1, 1 → 0.**	—
18	**0, 1, 1, 1, 1, 0, 1, 1**	000 → 0; 001 → 1; 010 → 1; 011 → 1; 100 → 1; 101 → 0; 110 → 1; 111 → 1
19	**(a) (A XOR B) OR C; (b) 1; (c) 6**	output column: 0, 1, 1, 1, 1, 1, 0, 1
20	**(a) 1, 0, 0, 0 and 1, 0, 0, 0: the columns are equal; (b) P OR NOT Q**	00 → 1; 01 → 0; 10 → 0; 11 → 0