1.7 Boolean Algebra, Logic Gates and Karnaugh Maps: Test Pack

Total Marks

OCR H446 · Calculators not allowed · about 25 minutes

Name: _____ Date: ____ / ____ / _____

Answer ALL questions. Show all your working.

1 This question is about basic logic gates and their truth tables.

(a) Complete the truth table for a 2-input AND gate, where Q is the output. **(1)**

A B	Q
0 0	?
0 1	?
1 0	?
1 1	?

(b) Complete the truth table for a 2-input XOR (exclusive OR) gate, where Q is the output. **(2)**

A B	Q
0 0	?
0 1	?
1 0	?
1 1	?

(c) A logic gate has the truth table below. **(1)**

A B	Q
0 0	1
0 1	1
1 0	1
1 1	0

Identify this gate.

(d) State the Boolean expression for a 2-input NOR gate with inputs A and B. **(1)**

(Total for Question 1 is 5 marks)

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2 This question is about the half adder circuit.

(a) State the Boolean expression for the Sum output, S, of a half adder in terms of inputs A and B. **(1)**

(b) State the Boolean expression for the Carry output, C, of a half adder in terms of inputs A and B. **(1)**

(c) Complete the truth table for a half adder. **(2)**

A B	S	C
0 0	?	?
0 1	?	?
1 0	?	?
1 1	?	?

(d) A half adder is built from a single XOR gate and a single AND gate. Explain why a half adder cannot, unmodified, add three single binary digits together (for example, two data bits plus a carry-in bit from a previous column). **(2)**

(Total for Question 2 is 6 marks)

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3 A Boolean function Q depends on four inputs, A, B, C and D, and is defined by Q = (A.B) + (C.D).

(a) Complete the 4x4 Karnaugh map for this function, with AB as rows and CD as columns, both in Gray-code order (00, 01, 11, 10). **(4)**

CD=00 CD=01 CD=11 CD=10
AB=00: ? ? ? ?
AB=01: ? ? ? ?
AB=11: ? ? ? ?
AB=10: ? ? ? ?

(b) Identify the two groups of four adjacent 1s in the map and state the Boolean term each one represents. **(2)**

(c) Hence state the minimised sum-of-products (SOP) expression for Q. **(1)**

(d) Using Boolean algebra (not the Karnaugh map), verify that your simplified expression from part (c) is equivalent to the original definition of Q by evaluating both for A=1, B=0, C=1, D=1. **(2)**

(Total for Question 3 is 9 marks)

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Mark scheme · 1.7 Boolean Algebra, Logic Gates and Karnaugh Maps: Test Pack

Question 1

(a) all four Q values correct: 0, 0, 0, 1 **B1**

(a) Answer: Q = 0, 0, 0, 1

(b) rows A=0,B=0 and A=0,B=1 correct: 0, 1 **B1**

(b) rows A=1,B=0 and A=1,B=1 correct: 1, 0 **B1**

(b) Answer: Q = 0, 1, 1, 0

(c) NAND (accept NOT-AND) **B1**

(c) Answer: NAND gate

(d) Q = NOT(A + B), oe e.g. Q = (A+B)' **B1**

(d) Answer: Q = NOT(A + B)

Question 2

(a) S = A XOR B, oe **B1**

(a) Answer: S = A XOR B

(b) C = A.B **B1**

(b) Answer: C = A.B

(c) S column fully correct: 0, 1, 1, 0 **B1**

(c) C column fully correct: 0, 0, 0, 1 **B1**

(c) Answer: S = 0,1,1,0 and C = 0,0,0,1

(d) a half adder only has two inputs (A and B) **B1**

(d) it has no third, carry-in input, so it cannot incorporate a carry produced by a previous column; a full adder (with a Cin input) is needed for this **B1**

(d) Answer: A half adder has only two inputs and no carry-in input, so it cannot combine a carry from a previous column with the two data bits; a full adder is required.

Question 3

(a) row AB=00 correct: 0, 0, 1, 0 **B1**

(a) row AB=01 correct: 0, 0, 1, 0 **B1**

(a) row AB=11 correct: 1, 1, 1, 1 **B1**

(a) row AB=10 correct: 0, 0, 1, 0 **B1**

(a) Answer: AB=00: 0,0,1,0 | AB=01: 0,0,1,0 | AB=11: 1,1,1,1 | AB=10: 0,0,1,0

(b) the entire AB=11 row (four cells) represents the term A.B **B1**

(b) the entire CD=11 column (four cells) represents the term C.D **B1**

(b) Answer: Row AB=11 gives A.B; column CD=11 gives C.D.

(c) Q = A.B + C.D **B1**

(c) Answer: Q = A.B + C.D

(d) correctly evaluates the map/original value at this input as Q=1 (row AB=10, column CD=11) **B1**

(d) substitutes into the simplified expression: A.B+C.D = (1.0)+(1.1) = 0+1 = 1, which matches **B1**

(d) Answer: Both give Q=1 for A=1,B=0,C=1,D=1.

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