MODULE Q BOOLEAN LOGIC · Q5

Completing a truth table for a logic circuit: mark scheme

21 marks · Cambridge 0478 syllabus 10.2: functions of logic gates (the binary output produced from all possible binary inputs); 10.3(b): complete a truth table from a (i) problem statement, (ii) logic expression, (iii) logic circuit

How to use. One mark per bullet point up to the max shown. **//** separates alternative answers. **8-row truth tables (questions 2, 3 and 4):** 4 marks for 8 correct outputs, 3 marks for 6 or 7 correct, 2 marks for 4 or 5 correct, 1 mark for 2 or 3 correct, 0 for fewer than 2. The working space column is not marked. Rows are in the order printed on the question paper (000 to 111). Example working is shown for teachers; any correct working is acceptable.

<table>
<tr><th>QUESTION</th><th>ANSWER</th><th>MARKS</th><th>GUIDANCE</th></tr>
<tr><td>1(a)
0478 10.3(b)</td><td>8 // eight</td><td>1</td><td>Accept 2^3. Do not accept 9 (heading counted).</td></tr>
<tr><td>1(b)
0478 10.3(b)</td><td>B: 0, 0, 1, 1, 0, 0, 1, 1 and C: 0, 1, 0, 1, 0, 1, 0, 1</td><td>1</td><td>Both columns needed for the mark. Accept any arrangement in which each of the eight combinations appears exactly once (e.g. C as 1, 0, 1, 0, ...), since the question asks only for every combination once; the usual binary order is shown.</td></tr>
<tr><td>2
0478 10.3(b) (iii)</td><td>X column: 1, 1, 0, 1, 0, 0, 0, 1
Award marks for correct X values using the 4/3/2/1 rule
<table>
<tr><th>A</th><th>B</th><th>C</th><th>A NOR B</th><th>B AND C</th><th>X</th></tr>
<tr><td>0</td><td>0</td><td>0</td><td>1</td><td>0</td><td>1</td></tr>
<tr><td>0</td><td>0</td><td>1</td><td>1</td><td>0</td><td>1</td></tr>
<tr><td>0</td><td>1</td><td>0</td><td>0</td><td>0</td><td>0</td></tr>
<tr><td>0</td><td>1</td><td>1</td><td>0</td><td>1</td><td>1</td></tr>
<tr><td>1</td><td>0</td><td>0</td><td>0</td><td>0</td><td>0</td></tr>
<tr><td>1</td><td>0</td><td>1</td><td>0</td><td>0</td><td>0</td></tr>
<tr><td>1</td><td>1</td><td>0</td><td>0</td><td>0</td><td>0</td></tr>
<tr><td>1</td><td>1</td><td>1</td><td>0</td><td>1</td><td>1</td></tr>
</table></td><td>4</td><td>Max 4. Common errors: treating the NOR gate as OR (gives X = 0 in rows 1–2); missing that B feeds both gates.</td></tr>
</table>

<table>
<tr><th>QUESTION</th><th>ANSWER</th><th>MARKS</th><th>GUIDANCE</th></tr>
<tr><td>3
0478 10.3(b)
(ii)</td><td>Z column: 1, 0, 1, 0, 0, 1, 0, 0
Award marks for correct Z values using the 4/3/2/1 rule
<table>
<tr><th>A</th><th>B</th><th>C</th><th>A XOR C</th><th>B AND C</th><th>Z</th></tr>
<tr><td>0</td><td>0</td><td>0</td><td>0</td><td>0</td><td>1</td></tr>
<tr><td>0</td><td>0</td><td>1</td><td>1</td><td>0</td><td>0</td></tr>
<tr><td>0</td><td>1</td><td>0</td><td>0</td><td>0</td><td>1</td></tr>
<tr><td>0</td><td>1</td><td>1</td><td>1</td><td>1</td><td>0</td></tr>
<tr><td>1</td><td>0</td><td>0</td><td>1</td><td>0</td><td>0</td></tr>
<tr><td>1</td><td>0</td><td>1</td><td>0</td><td>0</td><td>1</td></tr>
<tr><td>1</td><td>1</td><td>0</td><td>1</td><td>0</td><td>0</td></tr>
<tr><td>1</td><td>1</td><td>1</td><td>0</td><td>1</td><td>0</td></tr>
</table></td><td>4</td><td>Max 4. Common errors: XOR worked as OR (A XOR C is 0 when A = C = 1); NOR worked as OR.</td></tr>
<tr><td>4
0478 10.3(b)
(i)</td><td>W column: 0, 1, 0, 0, 0, 0, 1, 1
Award marks for correct W values using the 4/3/2/1 rule
W = (L AND (P NOR Q)) OR (P AND Q) // (L AND NOT P AND NOT Q) OR (P AND Q)
<table>
<tr><th>P</th><th>Q</th><th>L</th><th>P NOR Q</th><th>L AND (P NOR Q)</th><th>P AND Q</th><th>W</th></tr>
<tr><td>0</td><td>0</td><td>0</td><td>1</td><td>0</td><td>0</td><td>0</td></tr>
<tr><td>0</td><td>0</td><td>1</td><td>1</td><td>1</td><td>0</td><td>1</td></tr>
<tr><td>0</td><td>1</td><td>0</td><td>0</td><td>0</td><td>0</td><td>0</td></tr>
<tr><td>0</td><td>1</td><td>1</td><td>0</td><td>0</td><td>0</td><td>0</td></tr>
<tr><td>1</td><td>0</td><td>0</td><td>0</td><td>0</td><td>0</td><td>0</td></tr>
<tr><td>1</td><td>0</td><td>1</td><td>0</td><td>0</td><td>0</td><td>0</td></tr>
<tr><td>1</td><td>1</td><td>0</td><td>0</td><td>0</td><td>1</td><td>1</td></tr>
<tr><td>1</td><td>1</td><td>1</td><td>0</td><td>0</td><td>1</td><td>1</td></tr>
</table></td><td>4</td><td>Max 4. Working not marked. Common errors: W = 1 in row 1 (level not low, so no warning); W = 0 in row 7 (both pumps running gives a warning whatever the level).</td></tr>
<tr><td>5
0478 10.3(b)
(iii)</td><td>Row A=0, B=1, C=1 circled (printed 0, should be 1)
Row A=1, B=0, C=1 circled (printed 1, should be 0)
Row A=1, B=1, C=0 circled (printed 1, should be 0)
Correct X column: 0, 1, 0, 1, 1, 0, 0, 1
<table>
<tr><th>A</th><th>B</th><th>C</th><th>NOT B</th><th>A AND NOT B</th><th>Printed X</th><th>Correct X</th></tr>
<tr><td>0</td><td>0</td><td>0</td><td>1</td><td>0</td><td>0</td><td>0</td></tr>
<tr><td>0</td><td>0</td><td>1</td><td>1</td><td>0</td><td>1</td><td>1</td></tr>
<tr><td>0</td><td>1</td><td>0</td><td>0</td><td>0</td><td>0</td><td>0</td></tr>
<tr><td>0</td><td>1</td><td>1</td><td>0</td><td>0</td><td>0</td><td>1</td></tr>
<tr><td>1</td><td>0</td><td>0</td><td>1</td><td>1</td><td>1</td><td>1</td></tr>
<tr><td>1</td><td>0</td><td>1</td><td>1</td><td>1</td><td>1</td><td>0</td></tr>
<tr><td>1</td><td>1</td><td>0</td><td>0</td><td>0</td><td>1</td><td>0</td></tr>
<tr><td>1</td><td>1</td><td>1</td><td>0</td><td>0</td><td>1</td><td>1</td></tr>
</table></td><td>3</td><td>One mark for each correct value identified, max 3. Deduct one mark for each extra value circled (minimum 0). Accept the value identified another clear way (ticked, crossed, or the correct value written beside it).</td></tr>
</table>

<table>
<tr><th>QUESTION</th><th>ANSWER</th><th>MARKS</th><th>GUIDANCE</th></tr>
<tr><td>6(a)
0478 10.3(b)(iii)</td><td>A NAND B column: 1, 1, 1, 0
A OR B column: 0, 1, 1, 1
X column: 0, 1, 1, 0
<table><tr><th>A</th><th>B</th><th>A NAND B</th><th>A OR B</th><th>X</th></tr><tr><td>0</td><td>0</td><td>1</td><td>0</td><td>0</td></tr><tr><td>0</td><td>1</td><td>1</td><td>1</td><td>1</td></tr><tr><td>1</td><td>0</td><td>1</td><td>1</td><td>1</td></tr><tr><td>1</td><td>1</td><td>0</td><td>1</td><td>0</td></tr></table></td><td>3</td><td>One mark per correct column. FT: X correct for the candidate's two middle columns ANDed.</td></tr>
<tr><td>6(b)
0478 10.2</td><td>XOR // EOR // exclusive OR (gate)</td><td>1</td><td>Accept the XOR symbol drawn. FT from the candidate's X column if it matches a single 0478 gate (AND, OR, NAND, NOR). Without FT, do not accept OR.</td></tr>
</table>

Total: 21 marks