CAMBRIDGE IGCSE (0478)

Module Q: Boolean logic

Workbooklet mark scheme · 7 parts · 147 marks

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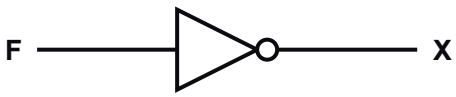
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	Total	**147**

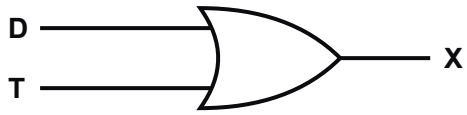
MODULE Q BOOLEAN LOGIC · Q1

Logic gates: AND, OR and NOT: mark scheme

20 marks · Cambridge 0478 syllabus 10.1 (standard symbols), 10.2 (functions of logic gates), 10.3 (circuits and expressions from a problem statement)

How to use. One mark per bullet point unless stated, up to the max shown. **//** separates alternative answers. Words in (brackets) are not needed for the mark. Logic circuits: the gate must be drawn with the standard 0478 symbol; a box with the gate's name written in it scores 0 for that gate. A NOT gate must have its small circle; an AND or OR gate must not have one. NOT has one input; AND and OR have exactly two inputs.

QUESTION	ANSWER	MARKS	GUIDANCE
1(a) 0478 10.1	One mark for each correct gate: Symbol 1: NOT Symbol 2: AND Symbol 3: OR	**3**	Do not accept NAND, NOR or XOR.
2(a) 0478 10.2	One mark for each correct row: Output 1 only when both inputs are 1: AND Opposite of its single input: NOT Output 0 only when both inputs are 0: OR	**3**	More than one gate written in a row: 0 for that row.
3(a) 0478 10.2	<table><tr><th>A</th><th>B</th><th>A AND B</th><th>A OR B</th></tr><tr><td>0</td><td>0</td><td>0</td><td>0</td></tr><tr><td>0</td><td>1</td><td>0</td><td>1</td></tr><tr><td>1</td><td>0</td><td>0</td><td>1</td></tr><tr><td>1</td><td>1</td><td>1</td><td>1</td></tr></table> One mark: A AND B rows 1-2 (0, 0) One mark: A AND B rows 3-4 (0, 1) One mark: A OR B rows 1-2 (0, 1) One mark: A OR B rows 3-4 (1, 1)	**4**	Each mark needs both outputs in that pair correct.
4(a) 0478 10.3(c)(i)	X = NOT F	**1**	Accept X = NOT(F). Do not accept "X = F NOT" or "X = F".
4(b) 0478 10.1, 10.3(a)(i)	Correct NOT symbol: triangle with a small circle at the output F as its only input and X as its output (no other gates) 	**2**	Triangle without the circle = 0 for the first mark. Second mark lost if any extra gate is drawn.
5(a) 0478 10.3(c)(i)	X = D OR T	**1**	Accept X = T OR D, X = (D OR T). Do not accept AND.

QUESTION	ANSWER	MARKS	GUIDANCE
5(b) 0478 10.1, 10.3(a)(i)	Correct OR symbol (curved back, pointed front, no circle) D and T as its two inputs and X as its output (no other gates) 	**2**	An XOR symbol (extra curved line at the inputs), a NOR symbol (circle at the output) or an AND symbol = 0 for the first mark. The second mark needs the first.
5(c) 0478 10.2	1	**1**	Accept "the buzzer sounds" // On // TRUE.
5(d) 0478 10.2	Any three from: AND only outputs 1 when both inputs are 1 A correct example where only one input is 1: D = 1, T = 0 (door open, temperature safe) // D = 0, T = 1 (door closed, temperature too high) ... ... AND would give X = 0 so the buzzer would not sound when it should // OR gives 1 for this combination The buzzer must sound when either condition happens on its own // when at least one input is 1	**3**	Max 3. The third bullet needs a correct example. Accept the example in words. An example with D = 1, T = 1 or D = 0, T = 0 earns no example mark (AND and OR give the same output). "AND is wrong" with no reason = 0. Credit any other valid explanation.

Total: 20 marks

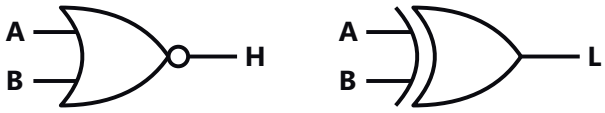
MODULE Q BOOLEAN LOGIC · Q2

NAND, NOR and XOR gates: mark scheme

21 marks · Cambridge 0478 syllabus 10.1 (logic gate symbols), 10.2 (functions of logic gates), 10.3(a)(i) (circuit from a problem statement), 10.3(b)(iii) (truth table from a logic circuit), 10.3(c)(i) and (ii) (logic expression from a problem statement and from a logic circuit)

How to use. One mark per creditworthy point up to the maximum shown. **/** separates alternative words; **//** separates alternative answers. Words in (brackets) are not needed for the mark. Gate symbols are marked on shape, not on any name written inside them. Accept EOR for XOR throughout. Accept TRUE/FALSE or T/F for 1/0 in truth tables. Credit any other valid answer that shows the same understanding.

<table>
<tr><th>QUESTION</th><th>ANSWER</th><th>MARKS</th><th>GUIDANCE</th></tr>
<tr><td>1(a)
0478 10.1</td><td>One mark for each correct gate:
• Gate 1: NOR
• Gate 2: XOR // EOR
• Gate 3: NAND</td><td>3</td><td>Accept NOT OR for NOR and NOT AND for NAND. Accept “exclusive OR” for XOR. Do not accept OR, AND or NOT alone.</td></tr>
<tr><td>2(a)
0478 10.2</td><td>One mark for each correct column:
<table><tr><th>A</th><th>B</th><th>A NAND B</th><th>A NOR B</th><th>A XOR B</th></tr><tr><td>0</td><td>0</td><td>1</td><td>1</td><td>0</td></tr><tr><td>0</td><td>1</td><td>1</td><td>0</td><td>1</td></tr><tr><td>1</td><td>0</td><td>1</td><td>0</td><td>1</td></tr><tr><td>1</td><td>1</td><td>0</td><td>0</td><td>0</td></tr></table></td><td>3</td><td>A column must have all four values correct to score its mark.</td></tr>
<tr><td>3(a)
0478 10.2</td><td>Any two from:
• output is 0 only when both inputs are 1
• output is 1 when either input or both inputs are 0 // output is 1 when the inputs are not both 1
• it gives the opposite/inverse of an AND gate // it is an AND gate followed by a NOT gate</td><td>2</td><td>A correct four-row truth table for NAND scores 2. “Output is 0 when both inputs are 1” and “output is 1 when either input is 0” are separate marks. Do not accept descriptions of NOR (e.g. “1 only when both inputs are 0”). “Opposite of AND” with no further detail = 1 mark only.</td></tr>
<tr><td>3(b)
0478 10.2</td><td>Any two from:
• when both inputs are 1, an OR gate outputs 1 …
• … but an XOR gate outputs 0
• an OR gate outputs 1 when either or both inputs are 1
• an XOR gate outputs 1 only when the inputs are different // when exactly one input is 1</td><td>2</td><td>Award the second bullet on its own (“XOR gives 0 when both inputs are 1”) even without the first. “XOR is exclusive” alone = 0. Do not accept answers saying the two gates differ when only one input is 1 (they both output 1).</td></tr>
</table>

<table>
<tr><th>QUESTION</th><th>ANSWER</th><th>MARKS</th><th>GUIDANCE</th></tr>
<tr><td>4(a)
0478 10.3(c)(i)</td><td>One mark for each correct expression:
• H = A NOR B
• L = A XOR B
• R = A NAND B</td><td>3</td><td>Accept correct equivalent expressions: H = NOT (A OR B) // (NOT A) AND (NOT B); L = (A AND NOT B) OR (NOT A AND B) // (A OR B) AND NOT (A AND B); R = NOT (A AND B) // (NOT A) OR (NOT B). Accept with or without the “H =” etc. Do not accept L = A OR B or R = NOT A AND B. Ignore missing brackets only when the meaning is still clear.</td></tr>
<tr><td>4(b)
0478 10.1, 10.3(a)(i)</td><td>One mark for each correct gate with inputs A and B:
• H: NOR gate
• L: XOR gate

</td><td>2</td><td>NOR must be the OR shape with the small circle at the output. XOR must have the extra curved line on the input side. A box with the gate name written in it = 0. The question asks for one gate per output: an OR gate followed by a NOT gate for H = 0. No follow-through from 4(a).</td></tr>
<tr><td>5(a)
0478 10.3(c)(ii)</td><td>One mark per correct part:
• (A NOR B)
• … XOR C
Answer: X = (A NOR B) XOR C</td><td>2</td><td>Accept NOT (A OR B) for A NOR B. Accept C XOR (A NOR B). The second mark needs XOR joining C to the output of the first gate. A NOR B XOR C with no brackets: max 1.</td></tr>
<tr><td>5(b)
0478 10.3(b)(iii)</td><td><table>
<tr><th>A</th><th>B</th><th>C</th><th>Working: A NOR B</th><th>X</th></tr>
<tr><td>0</td><td>0</td><td>0</td><td>1</td><td>1</td></tr>
<tr><td>0</td><td>0</td><td>1</td><td>1</td><td>0</td></tr>
<tr><td>0</td><td>1</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></tr>
<tr><td>1</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>1</td></tr>
<tr><td>1</td><td>1</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></tr>
</table>
4 marks for 8 correct outputs
3 marks for 6 or 7 correct outputs
2 marks for 4 or 5 correct outputs
1 mark for 2 or 3 correct outputs</td><td>4</td><td>Mark the X column only. The working space is not marked.</td></tr>
</table>

Total: 21 marks

MODULE Q BOOLEAN LOGIC · Q3

Truth tables for single gates: mark scheme

22 marks · Cambridge 0478 syllabus 10.1 (standard symbols for logic gates), 10.2 (functions of NOT, AND, OR, NAND, NOR, XOR: the binary output produced from all possible binary inputs), 10.3(a)(i) and 10.3(b)(i) (circuit and truth table from a problem statement), 10.3(c)(i) (logic expression from a problem statement)

How to use. One mark per creditworthy point up to the maximum shown. **/** separates alternative words; **//** separates alternative answers. Words in (brackets) are not needed for the mark. **...** means the mark depends on the point before it. Gate names must be the Cambridge names (NOT, AND, OR, NAND, NOR, XOR or EOR). Credit any other valid answer that shows the same understanding.

<table>
<tr><th>QUESTION</th><th>ANSWER</th><th>MARKS</th><th>GUIDANCE</th></tr>
<tr><td>1(a)
0478 10.2</td><td>• The (binary) output produced for all possible (combinations of binary) inputs</td><td>1</td><td>Do not accept “the inputs and outputs” without the idea of all possible inputs.</td></tr>
<tr><td>1(b)
0478 10.2</td><td>One mark for each:
• (i) 2
• (ii) 4</td><td>2</td><td>Ignore working. Do not accept 3 for (i) or 2 / 8 for (ii).</td></tr>
<tr><td>2(a)
0478 10.1, 10.2</td><td>For each gate: 2 marks for 4 correct outputs; 1 mark for 2 or 3 correct outputs
Gate 1 (NAND)<table><tr><th>A</th><th>B</th><th>X</th></tr><tr><td>0</td><td>0</td><td>1</td></tr><tr><td>0</td><td>1</td><td>1</td></tr><tr><td>1</td><td>0</td><td>1</td></tr><tr><td>1</td><td>1</td><td>0</td></tr></table>Gate 2 (NOR)<table><tr><th>A</th><th>B</th><th>X</th></tr><tr><td>0</td><td>0</td><td>1</td></tr><tr><td>0</td><td>1</td><td>0</td></tr><tr><td>1</td><td>0</td><td>0</td></tr><tr><td>1</td><td>1</td><td>0</td></tr></table>Gate 3 (XOR)<table><tr><th>A</th><th>B</th><th>X</th></tr><tr><td>0</td><td>0</td><td>0</td></tr><tr><td>0</td><td>1</td><td>1</td></tr><tr><td>1</td><td>0</td><td>1</td></tr><tr><td>1</td><td>1</td><td>0</td></tr></table></td><td>6</td><td>Max 2 per gate.
Mark each table on its own; the outputs must match the symbol shown.</td></tr>
<tr><td>3(a)
0478 10.2</td><td>One mark for each:
• E: NOR
• F: AND
• G: XOR // EOR
• H: OR</td><td>4</td><td>Accept a correct gate symbol in place of the name. Do not accept “NOT OR” for E or “exclusive” on its own for G.</td></tr>
<tr><td>4(a)
0478 10.2</td><td><table><tr><th>A</th><th>X</th></tr><tr><td>0</td><td>1</td></tr><tr><td>1</td><td>0</td></tr></table></td><td>1</td><td>Both rows needed.</td></tr>
</table>

<table>
<tr><th>QUESTION</th><th>ANSWER</th><th>MARKS</th><th>GUIDANCE</th></tr>
<tr><td>4(b)
0478 10.2</td><td>Any two from:
• The NAND output is the opposite / inverse of the AND output // NAND is AND followed by NOT // NAND = NOT (A AND B)
• … for every combination of inputs // in every row of the truth table
• e.g. when both inputs are 1, AND outputs 1 but NAND outputs 0 // when any input is 0, AND outputs 0 but NAND outputs 1</td><td>2</td><td>Accept “NAND is the opposite / NOT of AND” for the first point.
The first point can only be credited once.
Credit any other valid answer that shows the same understanding.</td></tr>
<tr><td>5(a)
0478 10.3(a)(i), 10.2</td><td>• NOR</td><td>1</td><td>Accept a correct NOR symbol.</td></tr>
<tr><td>5(b)
0478 10.3(b)(i)</td><td>2 marks for 4 correct outputs; 1 mark for 2 or 3 correct outputs
<table><tr><th>P</th><th>Q</th><th>W</th></tr><tr><td>0</td><td>0</td><td>1</td></tr><tr><td>0</td><td>1</td><td>0</td></tr><tr><td>1</td><td>0</td><td>0</td></tr><tr><td>1</td><td>1</td><td>0</td></tr></table></td><td>2</td><td>The table must match the scenario: no FT from (a).</td></tr>
<tr><td>5(c)
0478 10.3(c)(i)</td><td>• W = P NOR Q // W = NOT (P OR Q) // W = (NOT P) AND (NOT Q)</td><td>1</td><td>Accept the inputs in either order (Q NOR P).
Accept the expression without “W =”.
Do not accept NOT P OR Q without brackets, or symbols such as + or · in place of the operator words.</td></tr>
<tr><td>6(a)
0478 10.2</td><td>One mark for each:
• OR … A = 0 and B = 0
• NAND … A = 1 and B = 1</td><td>2</td><td>Each mark needs the gate and its matching inputs.
Either order. If more than two gates are given, mark the first two only.</td></tr>
</table>

Total: 22 marks

MODULE Q BOOLEAN LOGIC · Q4

Reading logic circuits: mark scheme

21 marks · Cambridge 0478 syllabus 10.1 (logic gate symbols), 10.2 (functions of NOT, AND, OR, NAND, NOR, XOR), 10.3(b)(iii) (complete a truth table from a logic circuit) and 10.3(c)(ii) (write a logic expression from a logic circuit)

How to use. One mark per bullet point up to the max shown. **//** separates alternative answers; **/** separates alternative words. Words in (brackets) are not needed for the mark. Credit any other valid answer that shows the same understanding. Accept T/F for 1/0. Accept EOR for XOR.

QUESTION	ANSWER	MARKS	GUIDANCE
1(a) 0478 10.1	Gate 1: NOR Gate 2: XOR // EOR	**2**	One mark each. Do not accept OR for gate 1 or OR for gate 2.
1(b) 0478 10.2, 10.3(b)(iii)	P = 1 X = 0	**2**	One mark each. 0 NOR 0 = 1; 1 XOR 1 = 0. Follow through: if P is wrong, X = P XOR 1 (the opposite of their P) scores the second mark.
2(a) 0478 10.3(b)(iii)	Output column X: A B C X 0 0 0 1 0 0 1 1 0 1 0 1 0 1 1 0 1 0 0 0 1 0 1 0 1 1 0 1 1 1 1 0	**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. The working space is not marked. X = (A NOR B) OR (B AND NOT C).
3(a) 0478 10.3(c)(ii)	X = (A XOR B) NOR (NOT C) One mark for each correct part: A XOR B NOT C … NOR … joining the two parts (with brackets showing the order)	**3**	Accept EOR for XOR. Accept X = (A XOR B) NOR NOT C. Do not accept a simplified expression for the third mark. Do not accept C NOT for NOT C.
4(a) 0478 10.2, 10.3(b)(iii)	P = 0 Q = 1	**2**	One mark each. Circuit 1: 1 OR 1 = 1, NOT gives 0. Circuit 2: NOT A = 0, 0 OR 1 = 1. The NOT gate only inverts the one signal on its line.
4(b) 0478 10.2	NOR	**1**	Do not accept NAND or OR.
5(a) 0478 10.3(b)(iii)	0 // fan off	**1**	Accept False.

QUESTION	ANSWER	MARKS	GUIDANCE
5(b) 0478 10.2, 10.3(b)(iii)	One mark each: the dust level is high // D = 1 … … or the workshop is too hot // or T = 1 // or both and the maintenance switch is off // M = 0	**3**	The first two marks need the "or" link: an answer that needs both D and T to be 1 scores max 1 of the first two marks. Do not accept "maintenance switch on" for the third mark. "D or T (or both) is 1 and M is 0" scores 3.
6(a) 0478 10.2, 10.3(b)(iii)	Max 3: the engineer is not correct, with a counter-example: A = 0, B = 1 and C = 1 A XOR B = 1 (because A and B are different) B NAND C = 0 (because B and C are both 1) … so X = 1 AND 0 = 0	**3**	"Not correct" with no reason scores 0. For full marks the answer must give, or clearly describe, A = 0, B = 1, C = 1 (the only case where A and B differ and X = 0). Credit working written on the circuit. "The engineer is correct" scores 0.

Total for this mark scheme: 21 marks

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>
<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>
</table>

<table>
<tr><th>QUESTION</th><th>ANSWER</th><th>MARKS</th><th>GUIDANCE</th></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>
<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>

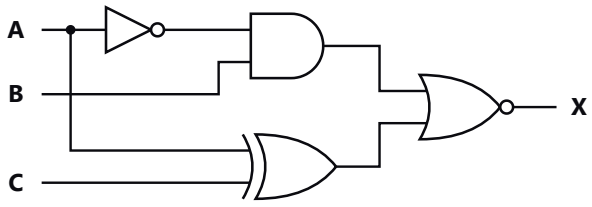
Total: 21 marks

MODULE Q BOOLEAN LOGIC · Q6

Logic expressions: writing them and drawing them: mark scheme

22 marks · Cambridge 0478 syllabus 10.1 (gate symbols), 10.2 (gate functions), 10.3(a)(ii) (circuit from a logic expression), 10.3(b)(ii) (truth table from a logic expression), 10.3(c)(i)-(iii) (logic expression from a problem statement, logic circuit or truth table)

How to use. One mark per bullet point up to the maximum shown. **//** separates alternative answers. Words in (brackets) are not needed for the mark. Logic expressions use NOT, AND, OR, NAND, NOR and XOR (accept EOR for XOR); capitals are not required. Accept any expression that gives the same output as the required one for every input, unless the guidance says otherwise. Credit any other valid answer that shows the same understanding.

QUESTION	ANSWER	MARKS	GUIDANCE
1(a) 0478 10.3(c)(ii), 10.1	One mark for each correct part: • `NOT A` • `B NOR C` • `XOR` joining the two parts Example: `X = (NOT A) XOR (B NOR C)`	**3**	Accept `NOT (B OR C)` for `B NOR C`. Brackets round `NOT A` not needed. The XOR mark needs both parts bracketed or clearly grouped as two separate parts. Do not accept `A NOT`. Do not accept `B OR C` (circle missed) for the second mark. `X =` not required.
2(a) 0478 10.3(a)(ii)	One mark for each correct logic gate with the correct inputs: • NOT gate with input A • AND gate with inputs NOT A and B • XOR gate with inputs A and C • NOR gate with inputs from the AND gate and the XOR gate 	**4**	Gates must use the 0478 symbols. Each logic gate must have a maximum of two inputs. A must reach both the NOT gate and the XOR gate (a branch from the A line, or A drawn twice, are both fine). Do not credit a gate drawn as a box with its name written in. A simplified circuit that is not drawn as given: credit only the gates that match the expression.
3(a) 0478 10.3(c)(iii)	One mark for each: • `(NOT A AND B AND C)` • `(A AND B AND NOT C)` • both terms joined with `OR` Example: `X = (NOT A AND B AND C) OR (A AND B AND NOT C)`	**3**	The OR mark needs at least one correct term. Accept the terms in either order and any extra brackets, e.g. `((NOT A) AND B) AND C`. Accept any correct equivalent expression for full marks, e.g. `B AND (A XOR C)`. An extra term for a row with output 0: max 2.

QUESTION	ANSWER	MARKS	GUIDANCE
4(a) 0478 10.3(c)(i)	One mark for each: • `A XOR B` • `NOT C` • both parts joined with `AND` Example: `X = (A XOR B) AND (NOT C)`	**3**	Accept the parts in either order. Accept `(A OR B) AND NOT (A AND B)` or `(A AND NOT B) OR (NOT A AND B)` for `A XOR B`. `A OR B` in place of XOR loses the first mark. Do not accept `C NOT`.
5(a) 0478 10.3(b)(ii)	<table><tr><th>A</th><th>B</th><th>X</th><th>Y</th></tr><tr><td>0</td><td>0</td><td>1</td><td>1</td></tr><tr><td>0</td><td>1</td><td>0</td><td>1</td></tr><tr><td>1</td><td>0</td><td>0</td><td>0</td></tr><tr><td>1</td><td>1</td><td>0</td><td>1</td></tr></table>	**4**	8 correct outputs: 4 marks; 6 or 7 correct: 3 marks; 4 or 5 correct: 2 marks; 2 or 3 correct: 1 mark. Working space not marked.
5(b) 0478 10.2	• NOR	**1**	Accept NOR drawn as its gate symbol. Do not accept NOT OR // OR then NOT (two gates, the question asks for a single gate). Do not accept NAND.
6(a) 0478 10.3(c)(ii), 10.1	One mark for each: • the gate giving output X // the last gate is an OR gate • replace it with an AND gate	**2**	The first mark needs the correct gate to be identified (the last / output gate, or the OR gate). The second mark needs AND to be named or drawn. Do not credit changing the NOT gate or the NAND gate.
6(b) 0478 10.3(c)(ii)	One mark for each: • `(B NAND C)` and `NOT A` both correct • joined with `OR` Example: `X = (B NAND C) OR (NOT A)`	**2**	Accept `NOT (B AND C)` for `B NAND C`. Accept the parts in either order. The intended expression `(B NAND C) AND (NOT A)` = max 1. Do not accept `B AND C` (circle missed) for the first mark.

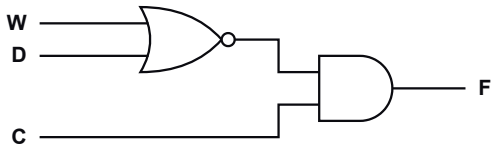
Total: 22 marks

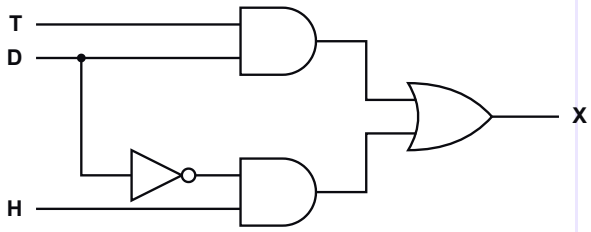
MODULE Q BOOLEAN LOGIC · Q7

From problem statement to logic circuit: mark scheme

20 marks · Cambridge 0478 syllabus 10.1 (standard logic gate symbols), 10.2 (functions of NOT, AND, OR, NAND, NOR, XOR), 10.3(a)(i) (create a logic circuit from a problem statement), 10.3(b)(i) (complete a truth table from a problem statement), 10.3(c)(i) (write a logic expression from a problem statement)

How to use. One mark per bullet point up to the maximum shown. **//** separates alternative answers. Words in (brackets) are not needed for the mark. Circuits: one mark for each correct gate with the correct inputs; each gate must have a maximum of two inputs; gates must be drawn with the 0478 section 4 symbols (a box with the gate name inside is not credited). Expressions: brackets must make the order clear; accept lower case.

QUESTION	ANSWER	MARKS	GUIDANCE
1 0478 10.2	A or B, but not both: **XOR** // EOR // exclusive OR neither A nor B: **NOR** // NOT OR not both A and B: **NAND** // NOT AND	**3**	One mark for each correct gate. Do not accept OR for row 1, or NOT for rows 2 and 3.
2(a) 0478 10.3(c)(i)	One mark per bullet point. Max 2. (W NOR D) // NOT (W OR D) // (NOT W AND NOT D) … AND C Example answer: `F = (W NOR D) AND C`	**2**	Second mark depends on a correct attempt at the first. Accept `C AND (W NOR D)`. Do not accept `(W OR D) AND C` or `(W NAND D) AND C`. Do not accept `NOT W OR D` (NOT applies only to W).
2(b) 0478 10.3(a)(i)	One mark for each correct gate with the correct inputs. Max 2. NOR gate with inputs W and D // OR gate with inputs W and D followed by a NOT gate // NOT W and NOT D into an AND gate AND gate with inputs C and the output of the first part, giving F Example answer:  	**2**	A three-input AND gate is not credited. The NOR gate must have its circle; an OR gate with no circle and no NOT gate scores 0 for the first mark.
3(a) 0478 10.3(c)(i)	One mark per bullet point. Max 3. (D AND T) (H AND NOT D) the two bracketed parts joined by OR Example answer: `X = (D AND T) OR (H AND NOT D)`	**3**	Accept the inputs in any order inside each bracket, e.g. `(T AND D) OR (NOT D AND H)`. Do not award the third mark if the brackets are missing so that the order is unclear. Do not accept `D NOT` for NOT D.

<table>
<tr><th>QUESTION</th><th>ANSWER</th><th>MARKS</th><th>GUIDANCE</th></tr>
<tr><td>3(b)
0478 10.3(a)(i)</td><td>One mark for each correct gate with the correct inputs. Max 4.
AND gate with inputs D and T
NOT gate with input D
AND gate with inputs H and the output of the NOT gate
OR gate with the outputs of the two AND gates as inputs, giving X
Example answer:

</td><td>4</td><td>The circuit must be drawn for the statement as given, without simplification. A gate with more than two inputs is not credited. The NOT gate must have its circle. Ignore whether input D is drawn once with a branch or written twice.</td></tr>
<tr><td>3(c)
0478 10.3(b)(i)</td><td><table>
<tr><th>D</th><th>T</th><th>H</th><th>X</th></tr>
<tr><td>0</td><td>0</td><td>0</td><td>0</td></tr>
<tr><td>0</td><td>0</td><td>1</td><td>1</td></tr>
<tr><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></tr>
<tr><td>1</td><td>0</td><td>0</td><td>0</td></tr>
<tr><td>1</td><td>0</td><td>1</td><td>0</td></tr>
<tr><td>1</td><td>1</td><td>0</td><td>1</td></tr>
<tr><td>1</td><td>1</td><td>1</td><td>1</td></tr>
</table></td><td>4</td><td>4 marks for 8 correct outputs; 3 marks for 6 or 7; 2 marks for 4 or 5; 1 mark for 2 or 3. The working space is not marked. Mark the table against the problem statement, not against the candidate's circuit.</td></tr>
<tr><td>4(a)
0478 10.2, 10.3(a)(i)</td><td>U = 1, L = 1, G = 1</td><td>1</td><td>All three values needed. (Both buttons pressed with the gate closed: the circuit gives 1 but the lift should not move.)</td></tr>
<tr><td>4(b)
0478 10.2</td><td>XOR // EOR // exclusive OR</td><td>1</td><td>Do not accept NOR, NAND or AND.</td></tr>
</table>

Total: 20 marks