1.4 DATA TYPES & STRUCTURES · 1.4.3

Karnaugh maps — Mark scheme

38 marks · spec 1.4.3(b) · all groupings verified

AO key: AO1 = knowledge · AO2 = application. Shaded squares = the 1s. Every grouping checked programmatically. Map layout: cols CD 00·01·11·10, rows AB 00·01·11·10.

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<tr><th>Q</th><th>ANSWER</th><th>AO</th><th>MARKS</th></tr>
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(a) ¬A·¬C — top-left block
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(b) B·D — centre block
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(c) ¬B·¬D — four corners
2 marks each: correct 1s placed (1) + correct single ring of four (1). (6)
</td><td>AO2</td><td>6</td></tr>
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<tr><th>Q</th><th>ANSWER</th><th>AO</th><th>MARKS</th></tr>
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Four 1s placed correctly (1); single group of four ringed (1); B is constant (=1) and D is constant (=1) across the group (1); simplified = `B · D` (1). (4)
</td><td>AO2</td><td>4</td></tr>
<tr><td>2(b)</td><td>
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Four corner 1s placed (1); grouped as one block of four via wrap-around (1); B = 0 and D = 0 across the group (1); simplified = `¬B · ¬D` (1). (4)
</td><td>AO2</td><td>4</td></tr>
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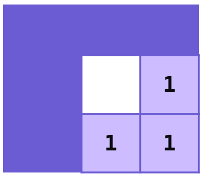
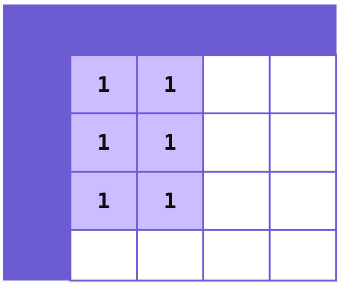
Q	ANSWER	AO	MARKS
3	 Three 1s placed (all except A=0,B=0) (1); ring the whole bottom row (A=1) → gives A (1); ring the right column (B=1) → gives B (1); result `A + B`, proving the identity (1). (4)	AO2	4

Q	ANSWER	AO	MARKS
4(a)	Two groups of four. (1)	AO2	1
4(b)	Centre block = `B·D` (1); four corners = `¬B·¬D` (1); expression = `B·D + ¬B·¬D` (1). (This is XNOR of B and D.) (3)	AO2	3
4(c)	The map wraps around: the left and right edges are adjacent, and the top and bottom edges are adjacent (1); so the four corners differ in only one variable from their neighbours and form a valid group of four (1). (2)	AO1	2

Q	ANSWER	AO	MARKS
5	(i) 1 (1); (ii) 2 (1); (iii) 4 (1); (iv) 8 (1). (Each missing variable doubles the number of squares.) (4)	AO2	4

Q	ANSWER	AO	MARKS
6(a)	 Six 1s placed correctly (1); group `¬A·¬C` = top-left four (rows 00, 01) (1); overlapping group `B·¬C` = rows 01, 11 in the left two columns (1). (3)	AO2	3
6(b)	`¬A·¬C + B·¬C` (2) (1 mark per correct term). Accept the further-factorised `¬C·(¬A + B)`.	AO2	2
6(c)	Two 2-input AND gates + one OR gate, plus inverters for ¬A and ¬C — accept "3 main gates (2 AND, 1 OR) plus NOT gates", or 1 AND + 1 OR + NOTs if the factorised form ¬C·(¬A+B) is used. (1)	AO2	1

Q	ANSWER	AO	MARKS
7(a)	Grouping relies on combining adjacent cells that differ in one variable, which cancels that variable (1); this halving/doubling only works for rectangular blocks of 1, 2, 4, 8… (powers of two) (1). (2)	AO1	2
7(b)	A larger group means more variables are constant-or-cancelled, so each product term has fewer variables (1); fewer/smaller terms = fewer gates = the simplest circuit (1). (2)	AO1	2

Total for worksheet: 38 marks