

QUESTION 5.



5 (a) (i) $\bar{A}.B.C + A.B.\bar{C} + A.B.C$

(ii)

		AB			
		00	01	11	10
C	0	0	0	1	0
	1	0	1	1	0

[1]

(iii)

		AB			
		00	01	11	10
C	0	0	0	1	0
	1	0	1	1	0

1 mark for each loop

Allow f.t. from (ii)

[2]

(iv) $X =$

$A.B + B.C$
Allow f.t. from (iii)

[1]

[1]



(b) (i)

		AB			
		00	01	11	10
CD	00	0	1	1	0
	01	0	0	0	0
	11	0	0	1	0
	10	0	1	1	0

1 mark row headings

1 mark column headings

1 mark per 2 correct rows (based on headings)

[4]

(ii)

		AB			
		00	01	11	10
CD	00	0	1	1	0
	01	0	0	0	0
	11	0	0	1	0
	10	0	1	1	0

1 mark for loop with two 1s

1 mark for looping the four 1s

[2]

(iii) $X = B.\bar{D} + A.B.C$

[1]

[1]

QUESTION 6.

5 (a) (i)

$$Z = P \cdot \overline{Q} \cdot \overline{R} + P \cdot \overline{Q} \cdot R + P \cdot Q \cdot R$$

(ii)

		PQ			
		00	01	11	10
R	0	0	0	0	1
	1	0	0	1	1

[1]

(iii) 1 mark each loop

		PQ			
		00	01	11	10
R	0	0	0	0	1
	1	0	0	1	1

Allow f.t. from (ii)

[2]

(iv)

$$Z = P \cdot \overline{Q} + P \cdot R$$

[1]

[1]

Allow f.t. from (iii)

(b) (i) 1 mark row headings. 1 mark column headings.
1 mark per 2 correct rows (based on headings)

		PQ			
		00	01	11	10
RS	00	0	0	0	0
	01	0	1	1	1
	11	0	1	1	0
	10	0	0	0	0

[4]

Page 6	Mark Scheme	
	Cambridge International A Level – October/November 2015	



- (ii) 1 mark for loop with two 1s; 1 mark for loop with four 1s

		PQ			
		00	01	11	10
RS	00	0	0	0	0
	01	0	1	1	1
	11	0	1	1	0
	10	0	0	0	0

Allow f.t. from (i)
 –1 for each incorrect grouping, max. 2 errors

[2]

- (iii)

$$Z = Q.S$$

[1]

$$+ P.R.\bar{S}$$

[1]

Allow f.t. from (ii) – 1 error if more than 2 terms

QUESTION 7.



Question	Answer																																																		
3(a)	$X = A.(\bar{B} + (B . C))$ $B.C$ $\bar{B} + B.C$ $A.$					1 1 1																																													
3(b)	<table><tr><th>A</th><th>B</th><th>C</th><th>Working Space</th><th>X</th></tr><tr><td>0</td><td>0</td><td>0</td><td></td><td>0</td></tr><tr><td>0</td><td>0</td><td>1</td><td></td><td>0</td></tr><tr><td>0</td><td>1</td><td>0</td><td></td><td>0</td></tr><tr><td>0</td><td>1</td><td>1</td><td></td><td>0</td></tr><tr><td>1</td><td>0</td><td>0</td><td></td><td>1</td></tr><tr><td>1</td><td>0</td><td>1</td><td></td><td>1</td></tr><tr><td>1</td><td>1</td><td>0</td><td></td><td>0</td></tr><tr><td>1</td><td>1</td><td>1</td><td></td><td>1</td></tr></table> 1 mark first four entries, 1 mark for the last four entries					A	B	C	Working Space	X	0	0	0		0	0	0	1		0	0	1	0		0	0	1	1		0	1	0	0		1	1	0	1		1	1	1	0		0	1	1	1		1	2
A	B	C	Working Space	X																																															
0	0	0		0																																															
0	0	1		0																																															
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3(c)(i)	AB <table><tr><td></td><td></td><td>00</td><td>01</td><td>11</td><td>10</td></tr><tr><td>C</td><td>0</td><td>0</td><td>0</td><td>0</td><td>1</td></tr><tr><td></td><td>1</td><td>0</td><td>0</td><td>1</td><td>1</td></tr></table>							00	01	11	10	C	0	0	0	0	1		1	0	0	1	1	1																											
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C	0	0	0	0	1																																														
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3(c)(ii)	AB <table><tr><td></td><td></td><td>00</td><td>01</td><td>11</td><td>10</td></tr><tr><td>C</td><td>0</td><td>0</td><td>0</td><td>0</td><td>1</td></tr><tr><td></td><td>1</td><td>0</td><td>0</td><td>1</td><td>1</td></tr></table>							00	01	11	10	C	0	0	0	0	1		1	0	0	1	1	2																											
		00	01	11	10																																														
C	0	0	0	0	1																																														
	1	0	0	1	1																																														
3(c)(iii)	$X = A.\bar{B} + A.C$ 1 1					2																																													
3(d)	$X = A.(\bar{B} + (B . C))$ $X = A.(\bar{B} + C)$ $X = A.\bar{B} + A.C$					1 2 1 (dependent mark – must be correct outcome from previous line)																																													

QUESTION 8.



Question	Answer																																														
3(a)	$S = (\overline{P} + (\overline{Q+R})) \cdot R$ $\overline{P}$ $(\overline{Q+R})$ $(\overline{P} + (\overline{Q+R}))$ $\cdot R$ (must be outside final brackets) Or $\overline{P}$ $(\overline{Q+R})$ $\overline{P} + (\overline{Q+R})$ $(\dots\dots\dots) \cdot R$	1 1 1 1 1 1 1 1																																													
3(b)	<table><tr><th>P</th><th>Q</th><th>R</th><th>Working space</th><th>S</th></tr><tr><td>0</td><td>0</td><td>0</td><td></td><td>0</td></tr><tr><td>0</td><td>0</td><td>1</td><td></td><td>1</td></tr><tr><td>0</td><td>1</td><td>0</td><td></td><td>0</td></tr><tr><td>0</td><td>1</td><td>1</td><td></td><td>1</td></tr><tr><td>1</td><td>0</td><td>0</td><td></td><td>0</td></tr><tr><td>1</td><td>0</td><td>1</td><td></td><td>0</td></tr><tr><td>1</td><td>1</td><td>0</td><td></td><td>0</td></tr><tr><td>1</td><td>1</td><td>1</td><td></td><td>0</td></tr></table> 2 marks all correct, 1 mark seven correct, 0 marks six or fewer correct	P	Q	R	Working space	S	0	0	0		0	0	0	1		1	0	1	0		0	0	1	1		1	1	0	0		0	1	0	1		0	1	1	0		0	1	1	1		0	2
P	Q	R	Working space	S																																											
0	0	0		0																																											
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0	1	1		1																																											
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1	1	0		0																																											
1	1	1		0																																											
3(c)(i)	<table><tr><th colspan="2"></th><th colspan="4">PQ</th></tr><tr><th colspan="2"></th><th>00</th><th>01</th><th>11</th><th>10</th></tr><tr><th rowspan="2">R</th><th>0</th><td>0</td><td>0</td><td>0</td><td>0</td></tr><tr><th>1</th><td>1</td><td>1</td><td>0</td><td>0</td></tr></table>			PQ						00	01	11	10	R	0	0	0	0	0	1	1	1	0	0	1																						
		PQ																																													
		00	01	11	10																																										
R	0	0	0	0	0																																										
	1	1	1	0	0																																										
3(c)(ii)	<table><tr><th colspan="2"></th><th colspan="4">PQ</th></tr><tr><th colspan="2"></th><th>00</th><th>01</th><th>11</th><th>10</th></tr><tr><th rowspan="2">R</th><th>0</th><td>0</td><td>0</td><td>0</td><td>0</td></tr><tr><th>1</th><td>1</td><td>1</td><td>0</td><td>0</td></tr></table>			PQ						00	01	11	10	R	0	0	0	0	0	1	1	1	0	0	1																						
		PQ																																													
		00	01	11	10																																										
R	0	0	0	0	0																																										
	1	1	1	0	0																																										
3(c)(iii)	$S = \overline{P} \cdot R$	1																																													



Question	Answer
3(d)	$S = (\bar{P} + (\overline{Q+R})) \cdot R$ $S = (\bar{P} + (\bar{Q} \cdot \bar{R})) \cdot R \quad // \quad \bar{P} \cdot R + (\overline{Q+R}) \cdot R$ $S = (\bar{P} \cdot R) + (\bar{Q} \cdot \bar{R} \cdot R)$ $S = \bar{P} \cdot R + \bar{Q} \cdot 0$ $S = \bar{P} \cdot R + 0$ $S = \bar{P} \cdot R$

QUESTION 9.



Question	Answer	Marks															
4(a)(i)	1 mark for 2 or 3 correct, 2 marks for 4 correct $X = \bar{A}.B.C + A.\bar{B}.C + A.B.\bar{C} + A.B.C$	2															
4(a)(ii)	1 mark for the correct K-map C AB <table><tr><td></td><td>00</td><td>01</td><td>11</td><td>10</td></tr><tr><td>0</td><td>0</td><td>0</td><td>1</td><td>0</td></tr><tr><td>1</td><td>0</td><td>1</td><td>1</td><td>1</td></tr></table>		00	01	11	10	0	0	0	1	0	1	0	1	1	1	1
	00	01	11	10													
0	0	0	1	0													
1	0	1	1	1													
4(a)(iii)	1 mark for each loop max 3 C AB <table><tr><td></td><td>00</td><td>01</td><td>11</td><td>10</td></tr><tr><td>0</td><td>0</td><td>0</td><td>1</td><td>0</td></tr><tr><td>1</td><td>0</td><td>1</td><td>1</td><td>1</td></tr></table>		00	01	11	10	0	0	0	1	0	1	0	1	1	1	3
	00	01	11	10													
0	0	0	1	0													
1	0	1	1	1													
4(a)(iv)	1 mark for each pair. Allow follow through from (iii) - A.B +B.C +A.C $X = A.B + B.C + A.C$	3															



Question	Answer																										
4(b)(i)	1 mark per bullet point max 2: • Correct column headings and row headings – values only • Correct column headings and row headings – order 1 mark for 2 correct rows or columns, 2 marks for 4 correct rows or columns (based on headings) AB <table><tr><td></td><td>00</td><td>01</td><td>11</td><td>10</td></tr><tr><td>00</td><td>0</td><td>1</td><td>1</td><td>0</td></tr><tr><td>01</td><td>0</td><td>0</td><td>1</td><td>0</td></tr><tr><td>11</td><td>0</td><td>0</td><td>1</td><td>0</td></tr><tr><td>10</td><td>0</td><td>0</td><td>1</td><td>0</td></tr></table> CD		00	01	11	10	00	0	1	1	0	01	0	0	1	0	11	0	0	1	0	10	0	0	1	0	
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11	0	0	1	0																							
10	0	0	1	0																							
4(b)(ii)	1 mark per loop AB <table><tr><td></td><td>00</td><td>01</td><td>11</td><td>10</td></tr><tr><td>00</td><td>0</td><td>1</td><td>1</td><td>0</td></tr><tr><td>01</td><td>0</td><td>0</td><td>1</td><td>0</td></tr><tr><td>11</td><td>0</td><td>0</td><td>1</td><td>0</td></tr><tr><td>10</td><td>0</td><td>0</td><td>1</td><td>0</td></tr></table> CD		00	01	11	10	00	0	1	1	0	01	0	0	1	0	11	0	0	1	0	10	0	0	1	0	2
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01	0	0	1	0																							
11	0	0	1	0																							
10	0	0	1	0																							
4(b)(iii)	1 mark per bullet point: • $A.B$ • $+B.\bar{C}.\bar{D}$ $X = A.B + B.\bar{C}.\bar{D}$	2																									

Question	Answer	Marks
3(a)	1 mark per bullet point to max 3: • Correct use of Idempotent law $Y = Y.Y$ $Y = Y + Y$ • Correct use of Complement law $0 = Y.\bar{Y}$ $1 = Y + \bar{Y}$ • Correct use of Distributive law $X(Y + Z) = X.Y + X.Z$ • Correct use of Redundancy law $X.\bar{Y} + Y = X + Y$ • Correct use of identity law $X.1 = X$ 1 mark for the correct answer For example: $X = A.\bar{B}.\bar{C} + A.B.\bar{C} + A.B.C$ Idempotent law $X = A.\bar{B}.\bar{C} + A.B.\bar{C} + A.B.\bar{C} + A.B.C$ Distributive law $X = A.\bar{C}.(B + \bar{B}) + A.B.(C + \bar{C})$ Complement/Inverse law $X = A.\bar{C} + A.B$ $X = A.(C + \bar{C})$ Correct answer $X = A.\bar{B}.\bar{C} + A.B.\bar{C} + A.B.C$ Distributive law $X = A.\bar{C}.(B + \bar{B}) + A.B.C$ Complement/Inverse law $X = A.\bar{C} + A.B.C$ $X = A.(C + B.C)$ Redundancy Law $X = A.(C + B)$ Correct answer	4

Question	Answer	Marks																																				
3(b)(i)	1 mark for first four as 0, 1 mark for 1011 <table><tr><th>A</th><th>B</th><th>C</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>0</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>0</td></tr><tr><td>1</td><td>0</td><td>0</td><td>1</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> 1 mark 1 mark	A	B	C	X	0	0	0	0	0	0	1	0	0	1	0	0	0	1	1	0	1	0	0	1	1	0	1	0	1	1	0	1	1	1	1	1	2
A	B	C	X																																			
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1	0	1	0																																			
1	1	0	1																																			
1	1	1	1																																			
3(b)(ii)	1 mark for correct K-map AB <table><tr><td></td><td>00</td><td>01</td><td>11</td><td>10</td></tr><tr><td>0</td><td>0</td><td>0</td><td>1</td><td>1</td></tr><tr><td>1</td><td>0</td><td>0</td><td>1</td><td>0</td></tr></table> C		00	01	11	10	0	0	0	1	1	1	0	0	1	0	1																					
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Question	Answer	Marks																									
3(b)(iii)	1 mark for each correct loop to max 2 AB <table><tr><td></td><td>00</td><td>01</td><td>11</td><td>10</td></tr><tr><td>0</td><td>0</td><td>0</td><td>1</td><td>1</td></tr><tr><td>1</td><td>0</td><td>0</td><td>1</td><td>0</td></tr></table> C		00	01	11	10	0	0	0	1	1	1	0	0	1	0	2										
	00	01	11	10																							
0	0	0	1	1																							
1	0	0	1	0																							
3(b)(iv)	1 mark per bullet point: A.C + A.B X = A.C + A.B	2																									
3(c)(i)	1 mark per bullet point to max 2: Correct column headings and row headings – values only Correct column headings and row headings – order 1 mark for 2 correct rows or columns, 2 marks for 4 correct rows or columns (based on headings) AB <table><tr><td></td><td>00</td><td>01</td><td>11</td><td>10</td></tr><tr><td>00</td><td>0</td><td>1</td><td>1</td><td>0</td></tr><tr><td>01</td><td>0</td><td>0</td><td>1</td><td>0</td></tr><tr><td>11</td><td>0</td><td>0</td><td>1</td><td>0</td></tr><tr><td>10</td><td>0</td><td>0</td><td>1</td><td>0</td></tr></table> CD		00	01	11	10	00	0	1	1	0	01	0	0	1	0	11	0	0	1	0	10	0	0	1	0	4
	00	01	11	10																							
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11	0	0	1	0																							
10	0	0	1	0																							

Question	Answer	Marks																									
3(c)(ii)	1 mark for each correct loop to max 2: AB <table><tr><td></td><td>00</td><td>01</td><td>11</td><td>10</td></tr><tr><td>00</td><td>0</td><td>1</td><td>1</td><td>0</td></tr><tr><td>01</td><td>0</td><td>0</td><td>1</td><td>0</td></tr><tr><td>11</td><td>0</td><td>0</td><td>1</td><td>0</td></tr><tr><td>10</td><td>0</td><td>0</td><td>1</td><td>0</td></tr></table> CD		00	01	11	10	00	0	1	1	0	01	0	0	1	0	11	0	0	1	0	10	0	0	1	0	2
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01	0	0	1	0																							
11	0	0	1	0																							
10	0	0	1	0																							
3(c)(iii)	1 mark per bullet point: • A.B • + B.C̄.D̄ X = A.B + B.C̄.D̄	2																									

QUESTION 11.



Question	Answer	Marks
3(a)(i)	00 01 11 10 0 1 1 0 1 1 1 1 0 1 C	1
3(a)(ii)	1 mark for each correct loop 00 01 11 10 0 1 1 0 1 1 1 1 0 1 C	2
3(a)(iii)	1 mark per bullet point • $\overline{A}$ • $+ \overline{B}$ $X = \overline{A} + \overline{B}$	2



Question	Answer																															
3(b)(i)	1 mark correct values and order of row and column headings 3 marks fully correct table entries (based on headings) or 2 marks table entries contain one error (based on headings) or 1 mark table entries contain two errors (based on headings) AB <table><tr><td></td><td></td><td>00</td><td>01</td><td>11</td><td>10</td></tr><tr><td></td><td>00</td><td>0</td><td>0</td><td>1</td><td>1</td></tr><tr><td></td><td>01</td><td>0</td><td>0</td><td>1</td><td>1</td></tr><tr><td>CD</td><td>11</td><td>1</td><td>1</td><td>0</td><td>0</td></tr><tr><td></td><td>10</td><td>1</td><td>1</td><td>0</td><td>0</td></tr></table>			00	01	11	10		00	0	0	1	1		01	0	0	1	1	CD	11	1	1	0	0		10	1	1	0	0	
		00	01	11	10																											
	00	0	0	1	1																											
	01	0	0	1	1																											
CD	11	1	1	0	0																											
	10	1	1	0	0																											
3(b)(ii)	1 mark per loop AB <table><tr><td></td><td></td><td>00</td><td>01</td><td>11</td><td>10</td></tr><tr><td></td><td>00</td><td>0</td><td>0</td><td>1</td><td>1</td></tr><tr><td></td><td>01</td><td>0</td><td>0</td><td>1</td><td>1</td></tr><tr><td>CD</td><td>11</td><td>1</td><td>1</td><td>0</td><td>0</td></tr><tr><td></td><td>10</td><td>1</td><td>1</td><td>0</td><td>0</td></tr></table>			00	01	11	10		00	0	0	1	1		01	0	0	1	1	CD	11	1	1	0	0		10	1	1	0	0	2
		00	01	11	10																											
	00	0	0	1	1																											
	01	0	0	1	1																											
CD	11	1	1	0	0																											
	10	1	1	0	0																											
3(b)(iii)	1 mark for each bullet point $\overline{A}.C$ $+ A.\overline{C}$ $X = \overline{A}.C + A.\overline{C}$	2																														

QUESTION 12.



Question	Answer																
4(a)	1 mark for 3 or 4 correct products 2 marks for all 5 correct products $X = \bar{A}.\bar{B}.\bar{C} + \bar{A}.\bar{B}.C + \bar{A}.B.\bar{C} + A.\bar{B}.\bar{C} + A.B.C$																
4(b)	1 mark for correct answer AB <table><tr><td></td><td>00</td><td>01</td><td>11</td><td>10</td></tr><tr><td>0</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>1</td><td>1</td></tr></table> C		00	01	11	10	0	1	0	0	0	1	1	1	1	1	1
	00	01	11	10													
0	1	0	0	0													
1	1	1	1	1													
4(c)	1 mark per correct loop AB <table><tr><td></td><td>00</td><td>01</td><td>11</td><td>10</td></tr><tr><td>0</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>1</td><td>1</td></tr></table> C		00	01	11	10	0	1	0	0	0	1	1	1	1	1	2
	00	01	11	10													
0	1	0	0	0													
1	1	1	1	1													
4(d)	1 mark per bullet point. $\bar{A}.\bar{B}$ $+C$ $X = \bar{A}.\bar{B} + C \text{ // } X = C + \bar{A}.\bar{B}$	2															

QUESTION 13.



Question	Answer																
2(a)(i)	1 mark for each 2 correct products, i.e. 3 marks for 6, 2 marks for 4 or 5, 1 mark for 2 or 3 $X = \overline{A}.\overline{B}.\overline{C} + \overline{A}.\overline{B}.C + \overline{A}.B.\overline{C} + \overline{A}.B.C + A.\overline{B}.\overline{C} + A.\overline{B}.C$																
2(a)(ii)	1 mark for the correct K-map AB <table><tr><td></td><td>00</td><td>01</td><td>11</td><td>10</td></tr><tr><td>0</td><td>1</td><td>1</td><td>0</td><td>1</td></tr><tr><td>1</td><td>1</td><td>1</td><td>0</td><td>1</td></tr></table> C		00	01	11	10	0	1	1	0	1	1	1	1	0	1	1
	00	01	11	10													
0	1	1	0	1													
1	1	1	0	1													
2(a)(iii)	1 mark for each correct loop AB <table><tr><td></td><td>00</td><td>01</td><td>11</td><td>10</td></tr><tr><td>0</td><td>1</td><td>1</td><td>0</td><td>1</td></tr><tr><td>1</td><td>1</td><td>1</td><td>0</td><td>1</td></tr></table> C		00	01	11	10	0	1	1	0	1	1	1	1	0	1	2
	00	01	11	10													
0	1	1	0	1													
1	1	1	0	1													
2(a)(iv)	1 mark per bullet point: • $\overline{A}$ • $+ \overline{B}$ $X = \overline{A} + \overline{B} // X = \overline{B} + \overline{A}$	2															
2(b)	$X = ((\overline{W} + X).(Y + \overline{Z}))$ One mark for correct use of <u>De Morgan's law</u> to + • $X = (\overline{W} + X) + (Y + \overline{Z})$ One mark for correct use of <u>De Morgan's law</u> + to • $X = \overline{\overline{W}.\overline{X}} + \overline{\overline{Y}.\overline{Z}}$ One mark for correct answer • $X = W.\overline{X} + \overline{Y}.Z$	3															