1

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

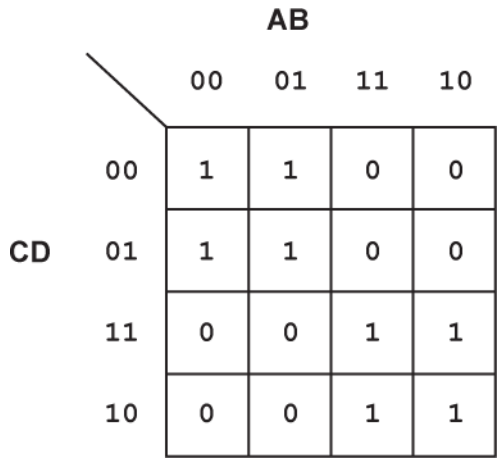
Fig. 9.1

State the Boolean expression represented by the Karnaugh map in Fig. 9.1, in its smallest form.

---

[4]

2 Draw the logic gates represented by the Karnaugh Map below. Show your working.



[4]

3(a) A Boolean expression is entered into a Karnaugh Map.

Give a simplified version of the expression using the Karnaugh Map. You must show your working.

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

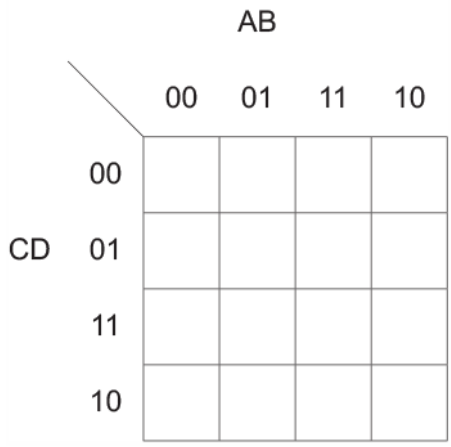
Simplified Expression: .....

[3]

(b) Draw a logic gate diagram to represent the expression below. **[4]**

$(\neg A \wedge B) \vee (\neg C \wedge D)$

(i) Complete the Karnaugh map below for the Boolean expression (¬ A ∧ ¬ B) ∨ (A ∧ ¬ B)



[3]

(ii) Use the Karnaugh map to find a simplified Boolean expression that is equivalent to (¬ A ∧ ¬ B) ∨ (A ∧ ¬ B)

---

[2]

5 Elliott has designed a logic circuit. The expression he has created for the logic circuit is:

$Q = (A \wedge \neg B) \vee (\neg A \wedge C \wedge D) \vee (A \wedge B)$

Complete the Karnaugh Map below to simplify this expression. Show your working.

CD \ AB	00	01	11	10
00				
01				
11				
10				

Simplified expression:

[4]

6(a)

A computer scientist has created the following logic circuit shown in **Fig. 6**.

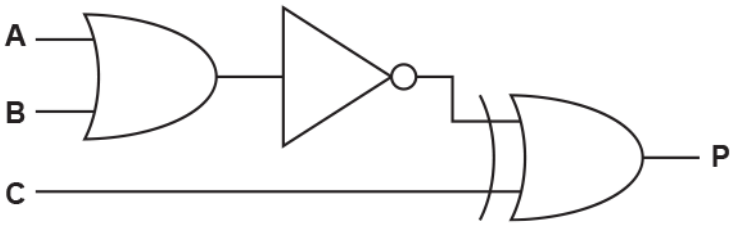


Fig. 6

(i) Give the Boolean expression that represents the logic circuit shown in **Fig. 6**. Do not attempt to simplify the expression.

---

[2]

(ii) Complete the truth table for the logic circuit shown in **Fig. 6.**

A	B	C	P
0	0	0	
0	0	1	
0	1	0	
0	1	1	
1	0	0	
1	0	1	
1	1	0	
1	1	1	

[3]

(b) The following Karnaugh map represents another logic circuit.

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

Use this Karnaugh map to find the simplified expression for this circuit.

You should highlight the map as appropriate and write the expression here.

[4]

7

Find the Boolean expression represented in the Karnaugh Map below. Show your working.

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

[5]

8 An electronics engineer needs a circuit with the following logic.

$(A \wedge B) \vee (\neg A \wedge B) \vee (\neg C \wedge \neg D)$

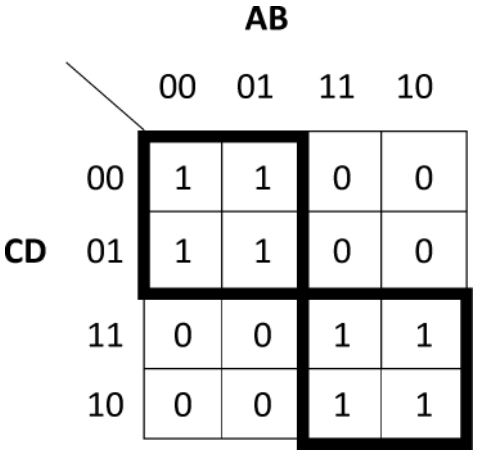
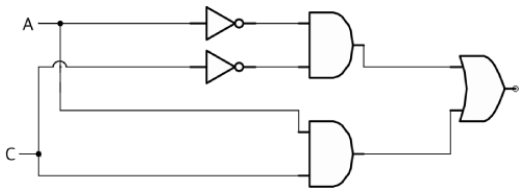
Complete and use the Karnaugh map below to simplify the expression above.

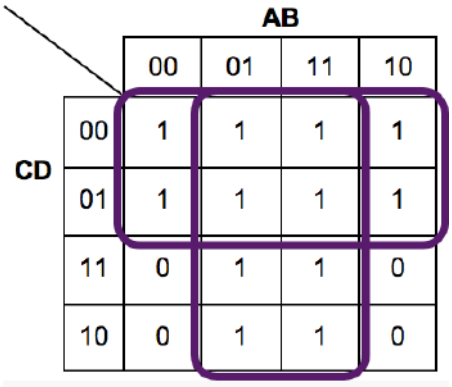
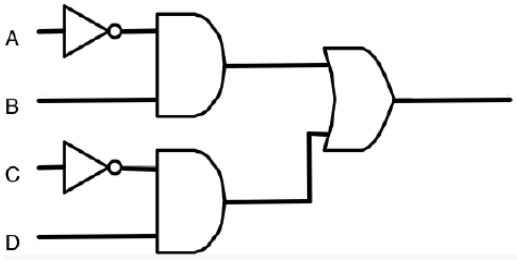
CD \ AB	00	01	11	10
00				
01				
11				
10				

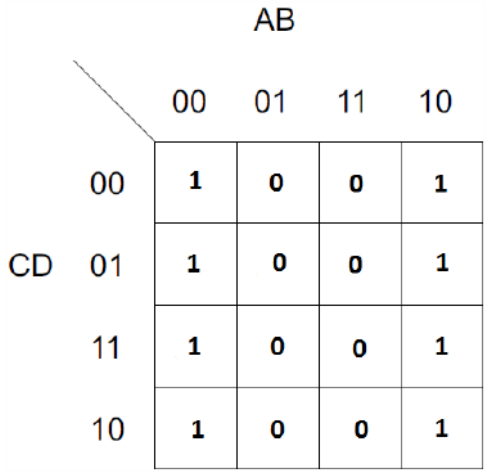
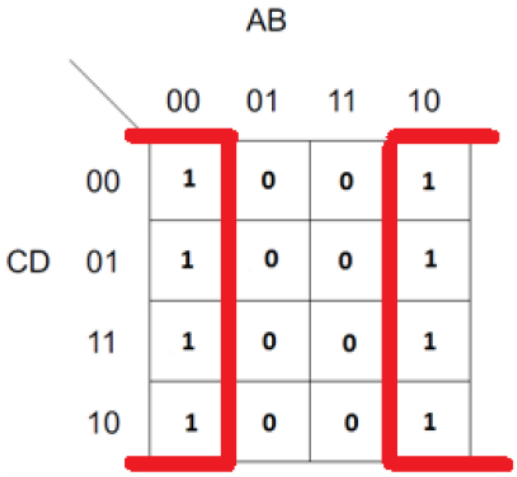
Simplified expression:

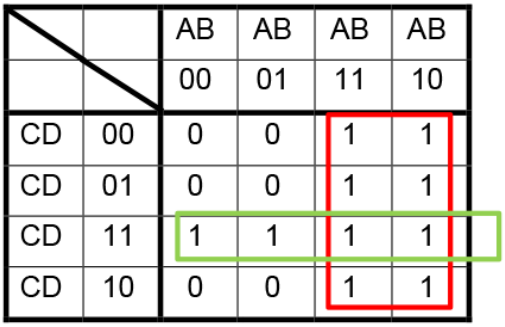
--- [4]

END OF QUESTION PAPER

Question			Answer/Indicative content	Marks	Guidance
1			(¬A ∧¬D) ∨(A ∧B ∧C) ∨(¬B ∧¬C ∧¬D) One mark for each bracketed section. One mark for them being joined with ORs	4	
			Total	4	
2			– Correctly identified groups on Karnaugh map / Correct boolean statement.(1) – NOT A AND NOT C Gates (1) – A AND C gates (1) – Both sets of gates joined by OR gate (with no other gates used). (1)	4 (AO2.2)	 (¬A ∧ ¬C) ∨ (A∧C) Or equivalent.  Or equivalent. **Examiner's Comments** Most candidates scored well on these questions demonstrating their understanding of logic gate circuits. Some candidates simplified the circuit in part b) which achieved full marks provided the resultant circuit gave the same output.
			Total	4	

Question			Answer/Indicative content	Marks	Guidance
3	a		 Gives: Bv¬C - Correct two groups identified. - Bv - ¬ (1 per -, max 3)	3 AO2.1 (1, 1st Mark) AO2.2 (2, Last 2 Marks)	Also accept: ¬C vB Accept alternative symbols. <u>Examiner's Comments</u> The question required candidates to find the Boolean expression represented in the Karnaugh Map. Most candidates achieved a mark for showing the correct groupings on the map. Many went on to achieve the marks for the resultant expression. Alternative notations were accepted and credited.
	b		- NOT gates after A and C - AND gates: one taking (NOT) A, B as inputs the other taking (NOT) C, D as inputs. - An OR gate taking in the outputs of both AND gates. - …No further gates or connections (1 per -, max 4)	4 AO2.2 (4)	 <u>Examiner's Comments</u> Most candidates achieved some credit on this question. There were some unusual representations for NOT gates. Candidates are best advised to use the representations listed in the appendix to the specification.
			Total	7	

Question			Answer/Indicative content	Marks	Guidance
4		i	• left column filled with 1s (¬ A ∧ ¬ B) … • right column filled with 1s (A ∧ ¬ B)… • …Middle 2 columns filled with zero or blank	3 AO1.2 (1) AO2.2 (2)	
		ii	• ¬ B / NOT B • Karnaugh map used to show 1s highlighted with overlap	2 AO2.2	
			Total	5	

Question			Answer/Indicative content	Marks	Guidance
5			Solution:  1 mark per bullet up to a maximum of 4 marks: • 1 mark for filling in the table correctly • 1 mark for the group shown in red • 1 mark for the group shown in green • 1 mark for the simplified expression $A \vee (C \wedge D)$	4 (AO2.1) (2) (AO2.2) (2)	Brackets are not required for the simplified expression Examiner's Comments This question was answered well with many candidates achieving all 4 marks. Some completed the table correctly but were not able to simplify the expression appropriately.
			Total	4	

<table>
<tr><th colspan="3">Question</th><th>Answer/Indicative content</th><th>Marks</th><th>Guidance</th></tr>
<tr><td>6</td><td>a</td><td>i</td><td>• ¬ (A ∨ B) // NOT (A OR B)
• ⊻ C // XOR C</td><td>2</td><td>First MP requires brackets, NOT A or B is incorrect.

Can be written in different order (e.g. C XOR NOT (B OR A) as long as logically correct.

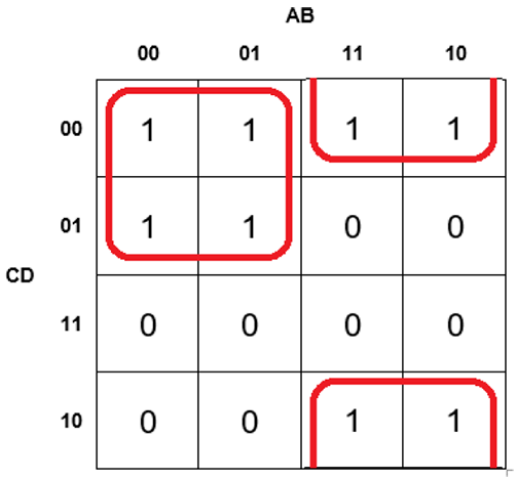
Accept $\overline{(A + B)} \oplus C$

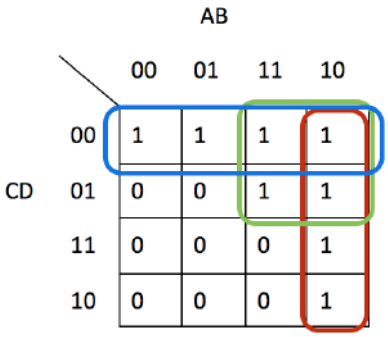
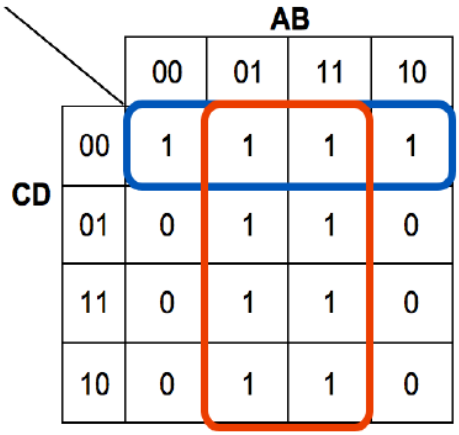
<u>Examiner's Comments</u>

This question was generally well answered, although some candidates confused AND and OR</td></tr>
<tr><td></td><td></td><td>ii</td><td>• 1 mark for first two rows (1,0)
• 1 mark for next two rows (0,1)
• 1 mark for next four rows (0,1,0,1)

<table>
<tr><th>A</th><th>B</th><th>C</th><th>P</th><th>Marking Guidance</th></tr>
<tr><td>0</td><td>0</td><td>0</td><td>1</td><td rowspan="2">1 Mark</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><td rowspan="2">1 Mark</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><td rowspan="4">1 Mark</td></tr>
<tr><td>1</td><td>0</td><td>1</td><td>1</td></tr>
<tr><td>1</td><td>1</td><td>0</td><td>0</td></tr>
<tr><td>1</td><td>1</td><td>1</td><td>1</td></tr>
</table>
</td><td>3</td><td><u>Examiner's Comments</u>

This question was generally well answered.</td></tr>
</table>

Question			Answer/Indicative content	Marks	Guidance
	b		• Correct highlighting on K map as shown • ¬A ∧ ¬C // $\overline{A}.\overline{C}$ // NOT A AND NOT C… • A ∧ ¬D // $A.\overline{D}$ D // A AND NOT D… • …∨ // + // OR joining the 2 correct expressions together	4	 Do not penalise candidates who attempt to simplify even further (e.g. NOT A AND NOT C = NOT (A OR C) using De Morgan's). MP1 - correct answer only MP4 is dependent on MP2 & 3 Examiner's Comments There were many candidates who were able to gain full marks on this question. Those who did not showed a lack of understanding of grouping on a Karnaugh map, either grouping to include zeros or missing the wrapping group and adding another group in for the top row.
			Total	9	

Question			Answer/Indicative content	Marks	Guidance
7			- Groups correctly identified (with no further groups). - Answer includes ¬ C∧¬D - Answer includes ¬ C∧¬D - Answer includes ¬ C∧¬D - All three sections joined with ∧s in any order but with no further sections. E.g. (A∧¬B)∨(A∧¬C)∨(¬ C∧¬D) The brackets aren't necessary (1 Mark per -, Max 5)	5 (AO1.2)	 <u>Examiner's Comments</u> The question required candidates to find the Boolean expression represented in the Karnaugh Map. Most candidates achieved a mark for showing the correct groupings on the map. Many went on to achieve some marks for the resultant expression. Some candidates specified NOT(C AND D) instead of NOT C AND NOT D evidently assuming the expressions are the same.
			Total	5	
8			Simplified expression: B v (¬C∧¬D) 	4	For 4 marks. 1 mark for simplified expression: B ∨ (¬C∧¬D) 1 mark for filling in table correctly. 1 mark for identifying each grouping (maximum 2). Allow follow through if tabled filled incorrectly giving one mark for each valid grouping if it is the most efficient possible to a maximum of two marks.
			Total	4	