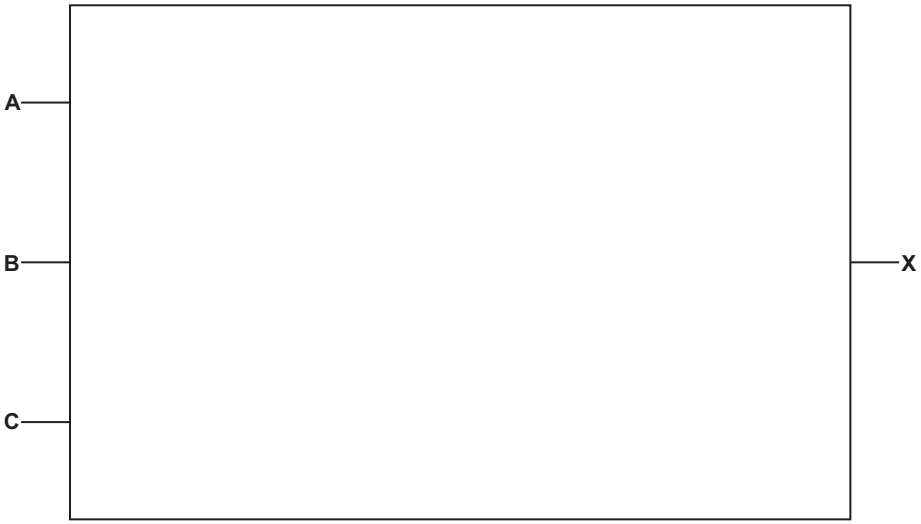
3 **(a)** Draw a logic circuit for the logic expression:

X = NOT ((**A** NAND **B**) XOR (NOT **A** OR NOT **C**))



[2]

(b) Write the logic expression for the following truth table.

R	S	T	Q
0	0	0	0
0	0	1	1
0	1	0	0
0	1	1	0
1	0	0	0
1	0	1	0
1	1	0	1
1	1	1	0

Q = ... [2]

3 **(a)** Complete the truth table for the following logic expression:

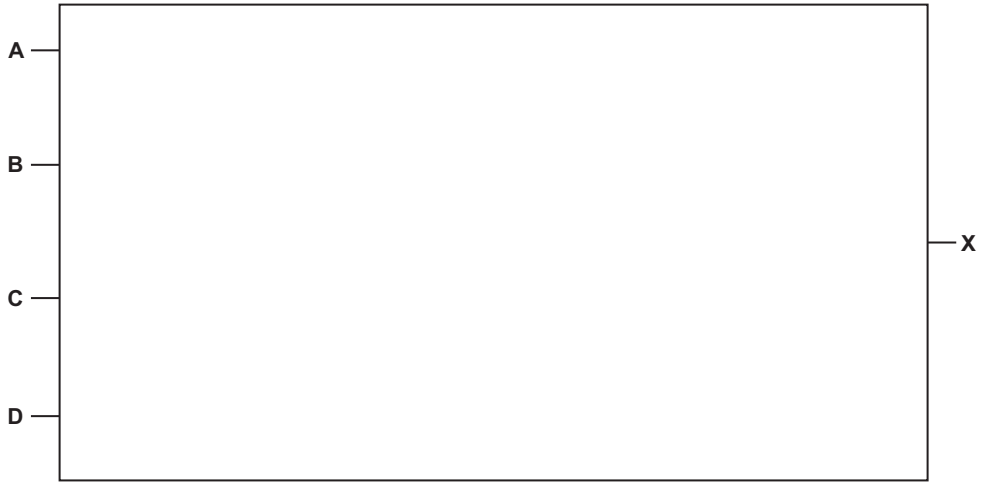
X = (**A** NOR **B**) NAND (**C** XOR **B**)

A	B	C	Working space	X
0	0	0		
0	0	1		
0	1	0		
0	1	1		
1	0	0		
1	0	1		
1	1	0		
1	1	1		

[2]

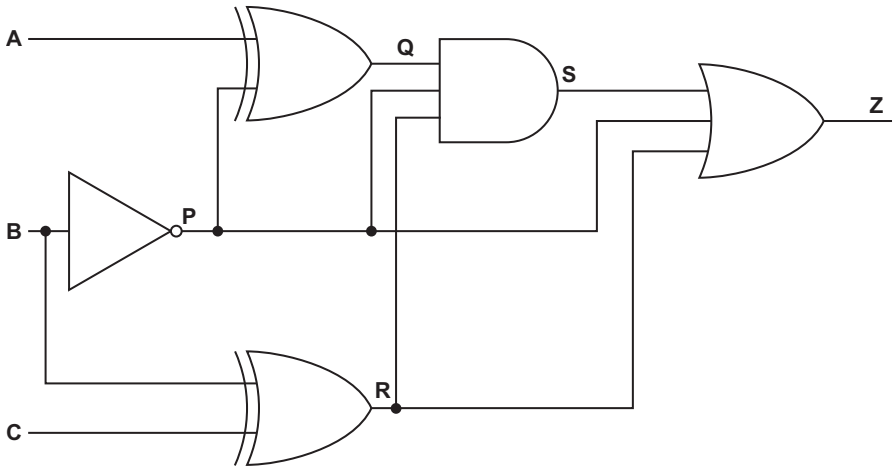
(b) Draw a logic circuit for the logic expression:

X = NOT (((**A** AND **B**) OR **C**) AND (**C** NOR **D**))



[2]

6 **(a)** The diagram shows a logic circuit.



Complete the truth table for the given logic circuit.
Show your working.

			Working space				
A	**B**	**C**	**P**	**Q**	**R**	**S**	**Z**
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) **(i)** Complete the Karnaugh map (K-map) for the Boolean expression:

$\overline{A}.\overline{B}.C + \overline{A}.B.C + A.\overline{B}.C + A.B.\overline{C}$

A \ BC	00	01	11	10
0				
1				

[2]

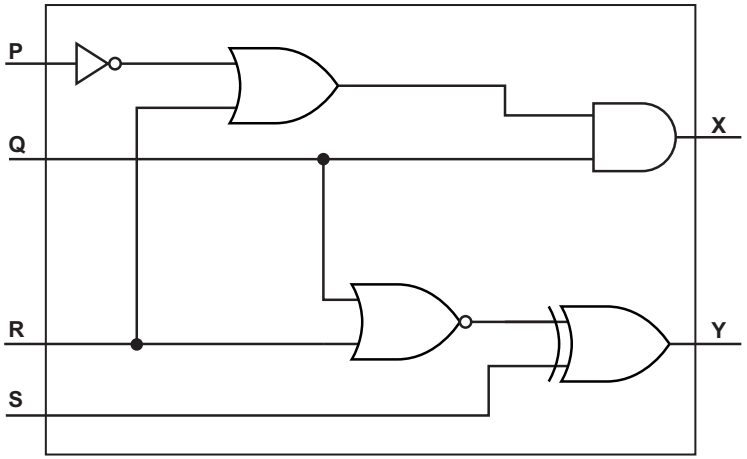
(ii) Draw loop(s) around appropriate group(s) in the K-map to produce an optimal sum-of-products. [2]

(iii) Write the Boolean expression from your answer to part **b(ii)** as a simplified sum-of-products. Do **not** carry out any further simplification.

.....

..... [2]

1 **(a)** Write the logic expressions for the following logic circuit.

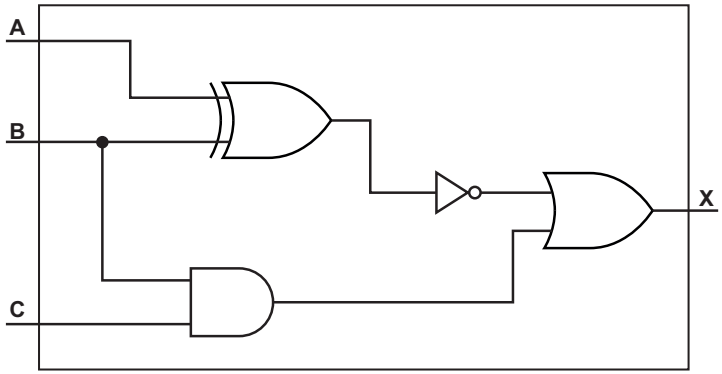


X = ...

Y = ...

[2]

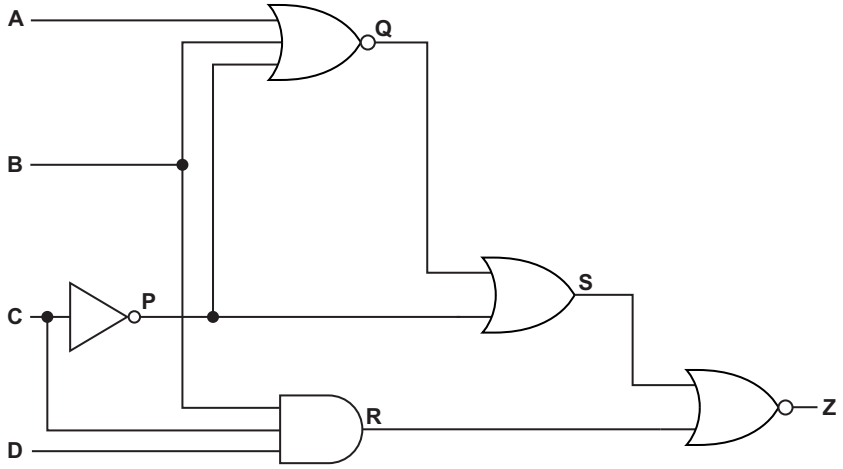
(b) Complete the truth table for the following logic circuit.



A	B	C	Working space	X
0	0	0		
0	0	1		
0	1	0		
0	1	1		
1	0	0		
1	0	1		
1	1	0		
1	1	1		

[2]

7 The diagram shows a logic circuit.



(a) Complete the truth table for the given logic circuit.
Show your working.

				Working space				
A	B	C	D	P	Q	R	S	Z
0	0	0	0					
0	0	0	1					
0	0	1	0					
0	0	1	1					
0	1	0	0					
0	1	0	1					
0	1	1	0					
0	1	1	1					
1	0	0	0					
1	0	0	1					
1	0	1	0					
1	0	1	1					
1	1	0	0					
1	1	0	1					
1	1	1	0					
1	1	1	1	6				

[3]

(b) Write the Boolean logic expression that corresponds to the given logic circuit as the sum-of-products.

Z = ...

..... [1]

(c) Use Boolean algebra including De Morgan's laws to simplify the following expression. Show all working.

$$(\overline{\mathbf{A} + \mathbf{B}}) \,.\, (\overline{\mathbf{A} \,.\, \mathbf{B}} + \overline{\mathbf{B} \,.\, \mathbf{C}})$$

Working .....

.....

.....

.....

.....

.....

Simplified expression .....

..... [4]

3 This truth table represents a logic circuit.

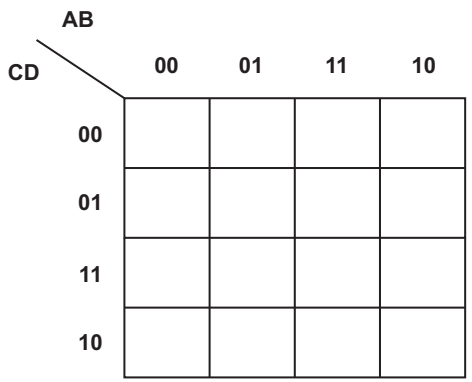
INPUT				OUTPUT
A	**B**	**C**	**D**	**Z**
0	0	0	0	0
0	0	0	1	0
0	0	1	0	1
0	0	1	1	1
0	1	0	0	1
0	1	0	1	0
0	1	1	0	0
0	1	1	1	0
1	0	0	0	0
1	0	0	1	0
1	0	1	0	1
1	0	1	1	1
1	1	0	0	1
1	1	0	1	0
1	1	1	0	0
1	1	1	1	0

(a) Write the Boolean logic expression that corresponds to the given truth table as the sum-of-products.

Z = ...

..... [2]

(b) (i) Complete the Karnaugh map (K-map) for the given truth table.



[2]

(ii) Draw loop(s) around appropriate group(s) in the K-map to produce an optimal sum-of-products. [2]

(iii) Write the Boolean logic expression from your answer to part **(b)(ii)** as the simplified sum-of-products.

Z = ...

..... [2]

5 A security system has both a floodlight (very bright light) and an audio alarm.

The data from multiple sensors is analysed and used to:

- turn on the floodlight
- sound the audio alarm.

Sensors can be used to detect:

- if doors are open
- the external daylight level
- if people are detected within a set distance.

(a) Complete the table to identify the most appropriate type of sensor for each scenario.

Scenario	Type of sensor
A door is open.	
The external daylight level is below a set amount.	
A person is detected within 2 metres.	

[1]

(b) The floodlight (**X**) and audio alarm (**Y**) operate according to the following criteria:

Parameter	Description of parameter	Binary value	Condition
A	external daylight level	1	Low
		0	High
B	front door	1	Open
		0	Closed
C	person is within 2 m	1	Detected
		0	Not detected
D	back door	1	Open
		0	Closed
E	security system	1	Switched on
		0	Switched off

The floodlight turns on (**X = 1**) if:

- the security system is switched on
  and
- the external daylight level is low
  and
- a person is detected within 2 m.

The audio alarm turns on (**Y = 1**) if:

- the security system is switched on
  and
- one **or** more doors are open, **or** a person is detected within 2 m.

Write logic expressions for the security system.

X = ...

.....

Y = ...

.....

[2]

(c) Explain whether the security system is an example of a monitoring system or a control system.

.....

.....

.....

.....

.....

....

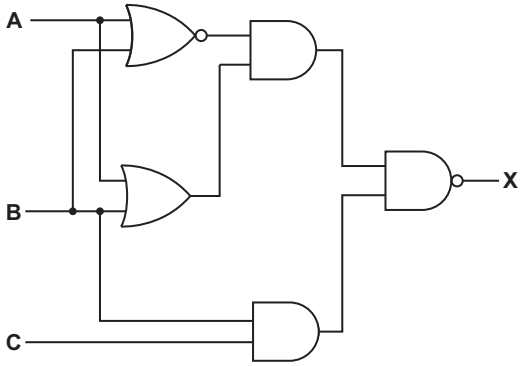
[3]

1 **(a)** Describe the operation of a 2-input XOR gate.

.....

..... [1]

(b) Write the logic expression for the following logic circuit.

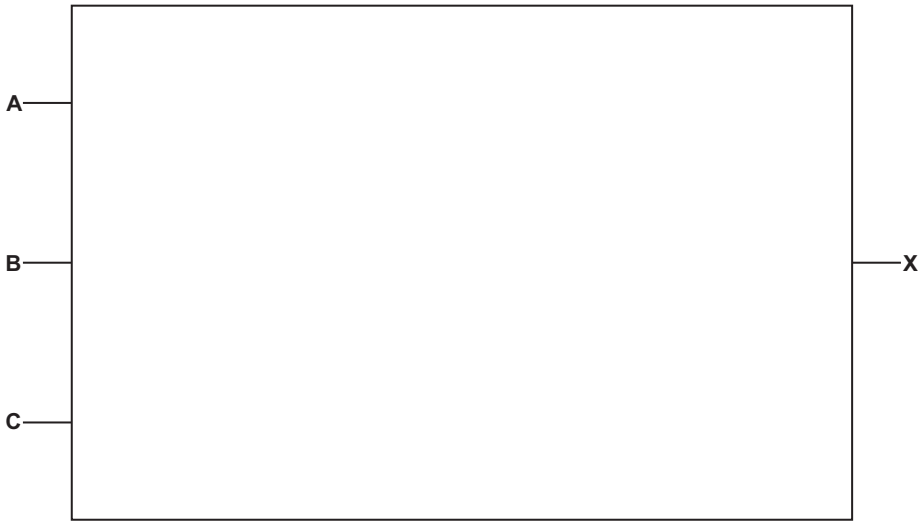


X = ...

..... [2]

(c) Draw the logic circuit for the logic expression:

X = ((NOT **A** AND (**B** AND **C**)) OR (**B** NAND **C**)) AND NOT **A**



[2]

1 **(a)** Describe the operation of each of the following logic gates:

NAND .....

.....

NOR .....

.....

XOR .....

.....

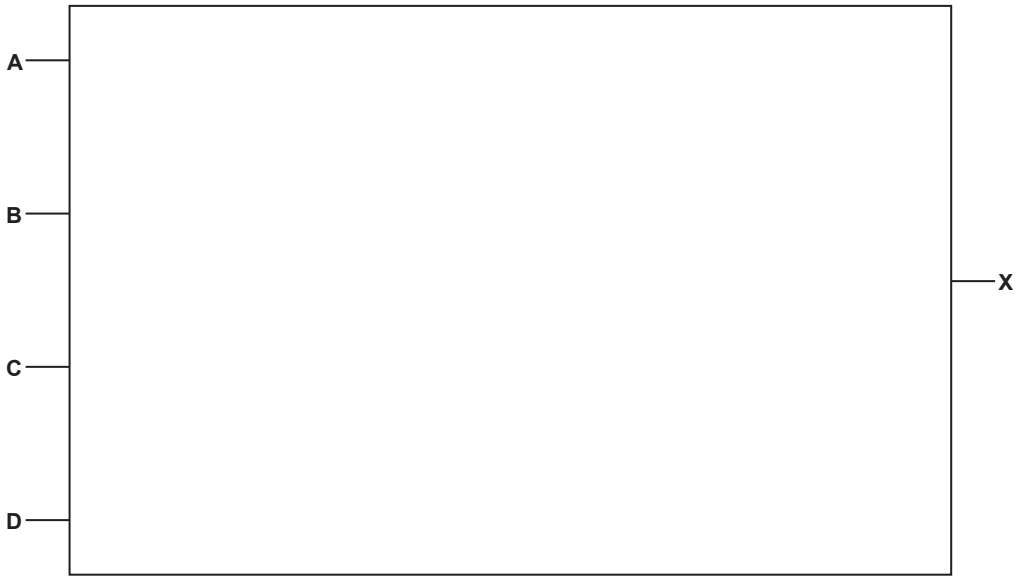
OR .....

.....

[4]

(b) Draw a logic circuit for this logic expression:

X = NOT ((**A** AND **B**) OR (**C** AND **D**))



[2]