Logic Gates

Papers Dock

COMPUTER SCIENCE 9618 PAPER 1

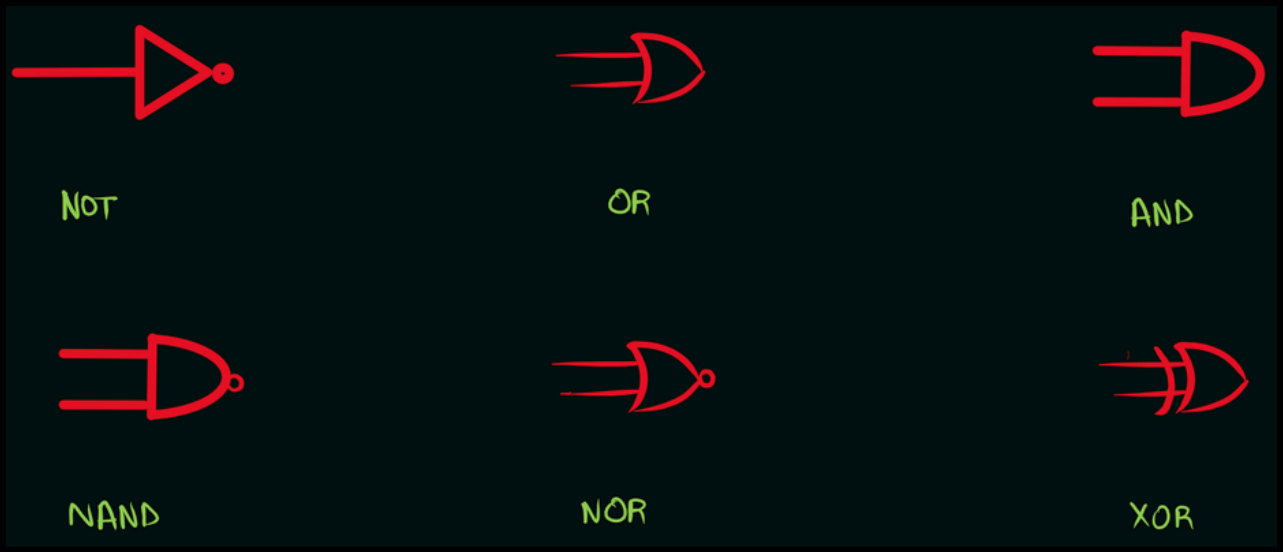
Logic Gates

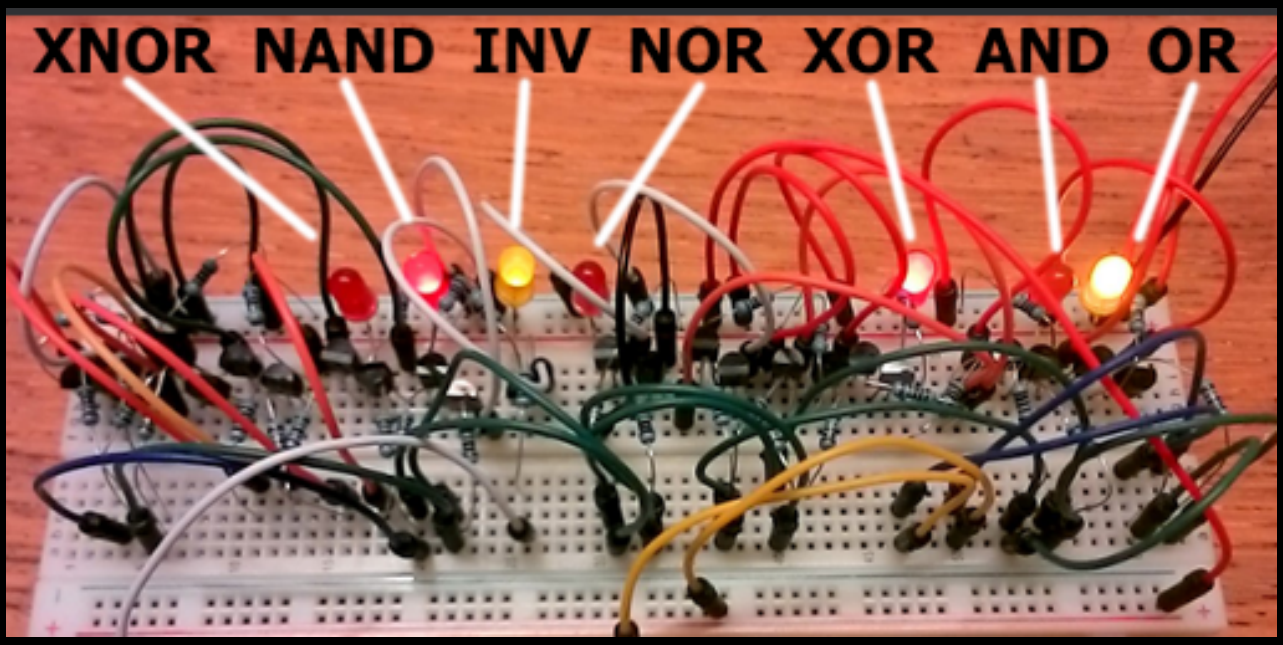
Logic gates are the basic building blocks of digital electronics. They perform logical operations on one or more binary inputs to produce a single binary output. The binary system uses two states: '1' (high or true) and '0' (low or false). Logic gates are used in various electronic devices and systems to process and manipulate data, perform calculations, and control hardware operations.

For example, a temperature sensor might detect when the temperature reaches a certain point and send a signal to a logic gate, which then turns on a fan. Sensors and logic gates together make it possible for electronic devices to respond to changes in their surroundings automatically.

Symbol Of Logic Gates

The symbols used for logic gates are standardized graphical representations that help people understand and design digital circuits.





Truth Table

Truth tables are used to trace the output from a logic gate or logic circuit. The NOT Gate is the only logic gate with one input. When constructing truth tables, all possible combination of 1's and 0's are considered.

$2^2 = 4$

Inputs	
A	**B**
0	0
0	1
1	0
1	1

$2^3 = 8$

Inputs		
A	B	C
0	0	0
0	0	1
0	1	0
0	1	1
1	0	0
1	0	1
1	1	0
1	1	1

NOT

Input	Output
A	X
0	1
1	0

X = NOT A (Logic Notation)

$X = \bar{A}$ (Boolean Algebra)

OR

Input		Output
A	B	X
0	0	0
0	1	1
1	0	1
1	1	1

If even one input is 1 then output is 1

X = A OR B (logic Notation)

$X = A + B$ (Boolean Algebra)

AND

Input		Output
A	B	X
0	0	0
0	1	0
1	0	0
1	1	1

If even one input is 0 then the output is 0

X = A AND B (logic Notation)

$X = A \cdot B$ (Boolean algebra)

NAND

Input		Output
A	B	X
0	0	1
0	1	1
1	0	1
1	1	0

Inverse the output of AND

X = A NAND B (logic Notation)

$X = \overline{A \cdot B}$ (Boolean Algebra)

NOR

Input		Output
A	B	X
0	0	1
0	1	0
1	0	0
1	1	0

Inverse the output of OR

$X = A \text{ NOR } B$ (Logic Notation)

$X = \overline{A + B}$ (Boolean Algebra)

XOR

Input		Output
A	B	X
0	0	0
0	1	1
1	0	1
1	1	0

Same input, the output would be 0

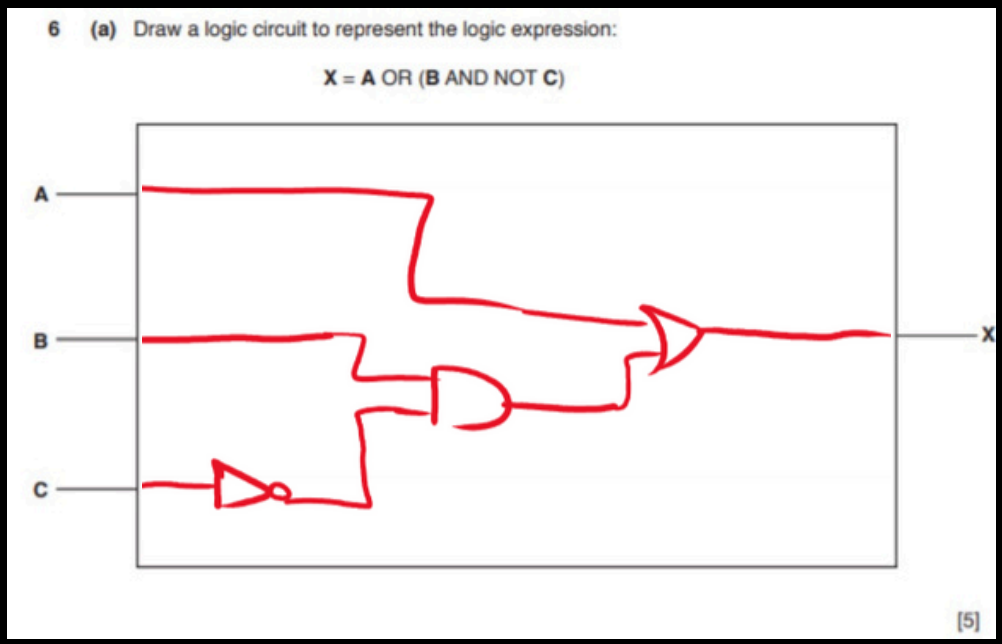
different input, the output would be 1

$X = A \text{ XOR } B$ (Logic Notation)

$X = A \oplus B$ (Boolean Algebra)

Logic Circuit

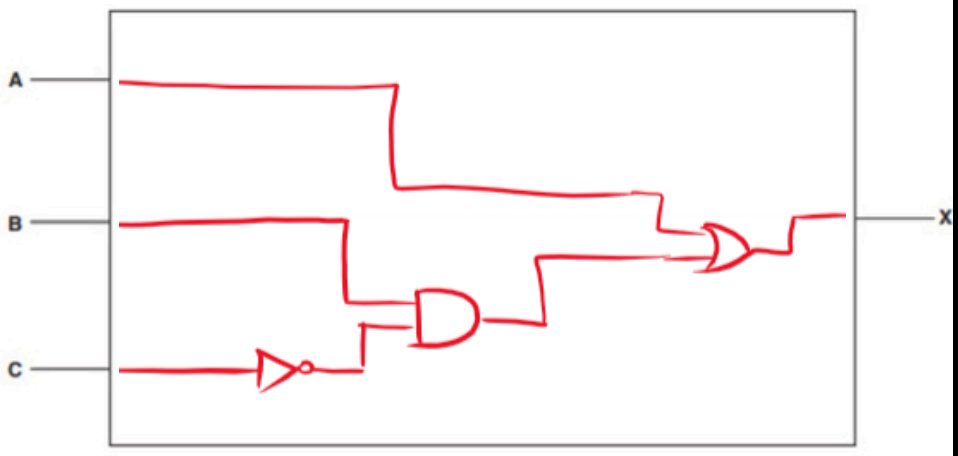
A logic circuit is a setup where different logic gates are connected to take in signals (like on/off) and produce a specific result. These circuits help devices like computers make decisions and perform tasks.



Case I : Construct A Logic Circuit By Logic Expression

6 **(a)** Draw a logic circuit to represent the logic expression:

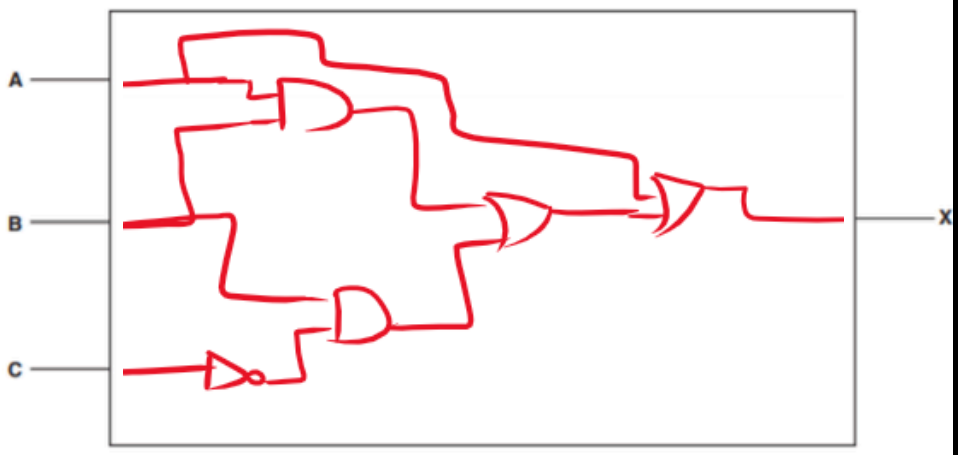
X = **A** OR (**B** AND NOT **C**)



[5]

6 **(a)** Draw a logic circuit to represent the logic expression:

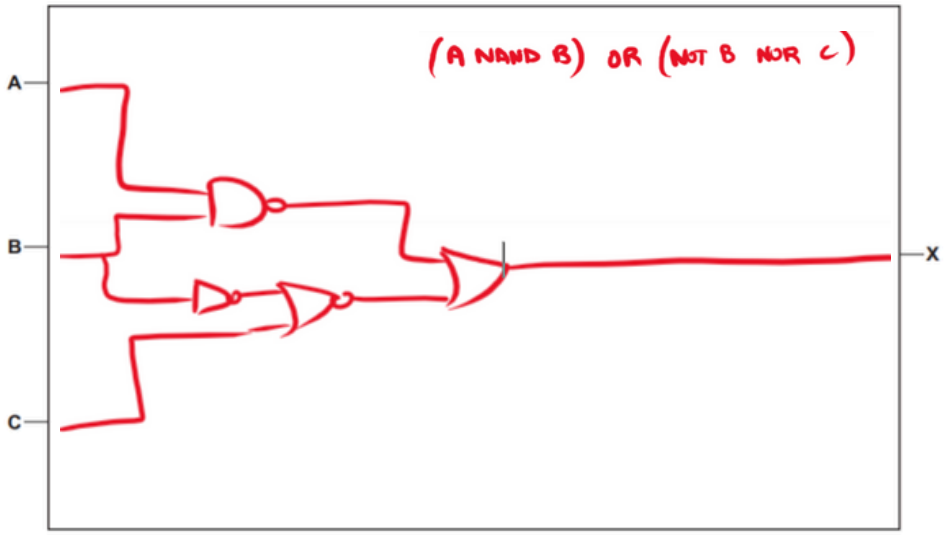
X = **A** OR (**B** AND NOT **C**) OR (**A** AND **B**)



[5]

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

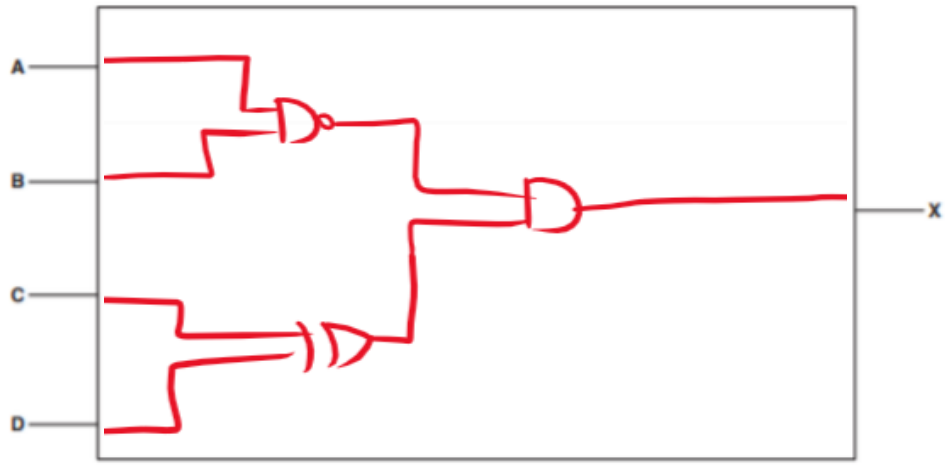
Draw the logic circuit for the given expression using a maximum of **four** gates.



[4]

2 **(a)** Draw a logic circuit to represent the following logic expression:

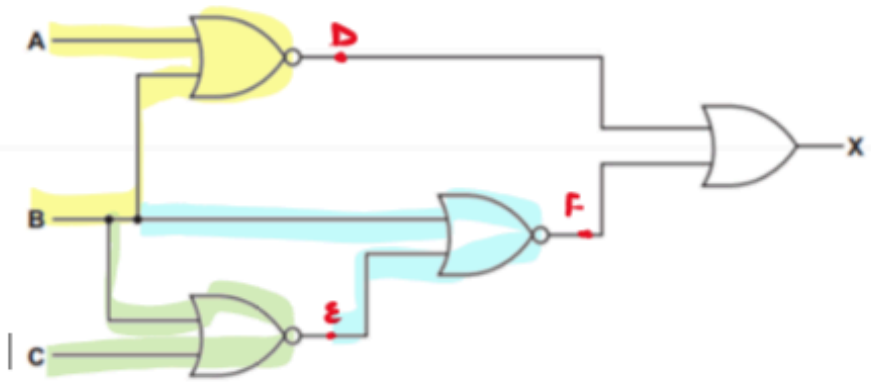
X = NOT (**A** AND **B**) AND (**C** XOR **D**)



[4]

Case 2 : Construct A Truth Table By Logic Circuit

8 (a) Complete the truth table for the following logic circuit:

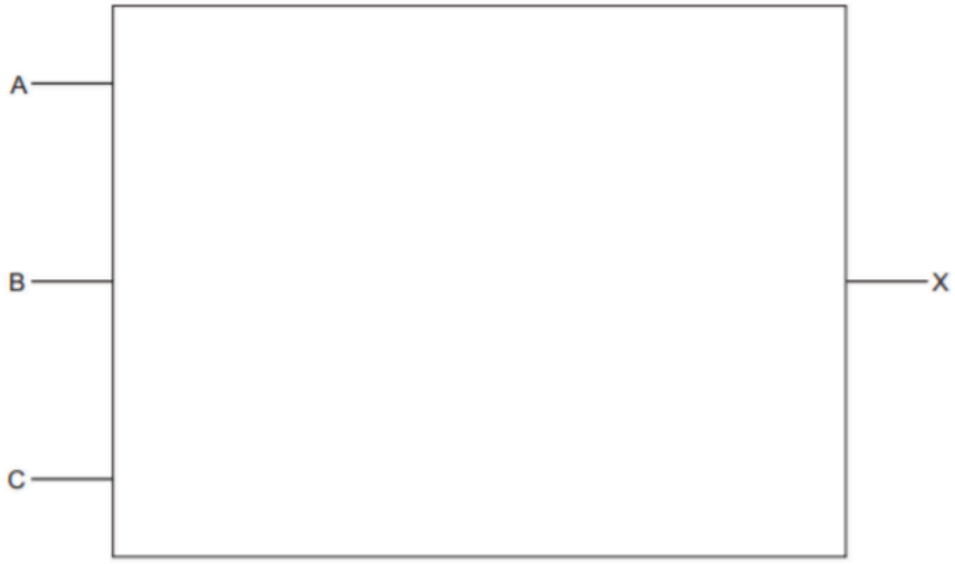


A	B	C	D	E	B	F	working	D		X
0	0	0	1	1	0	0		1		1
0	0	1	1	0	0	1		-		1
0	1	0	0	0	1	0		0		0
0	1	1	0	0	1	0		0		0
1	0	0	0	1	0	0		0		0
1	0	1	0	0	0	1		0		1
1	1	0	0	0	1	0		0		0
1	1	1	0	0	1	0		0		0

[4]

4 **(a)** Draw the logic circuit that directly corresponds to the following logic statement:

X = 1 IF (A is NOT 1 OR B is 1) AND (B is 1 OR C is 1)



[4]

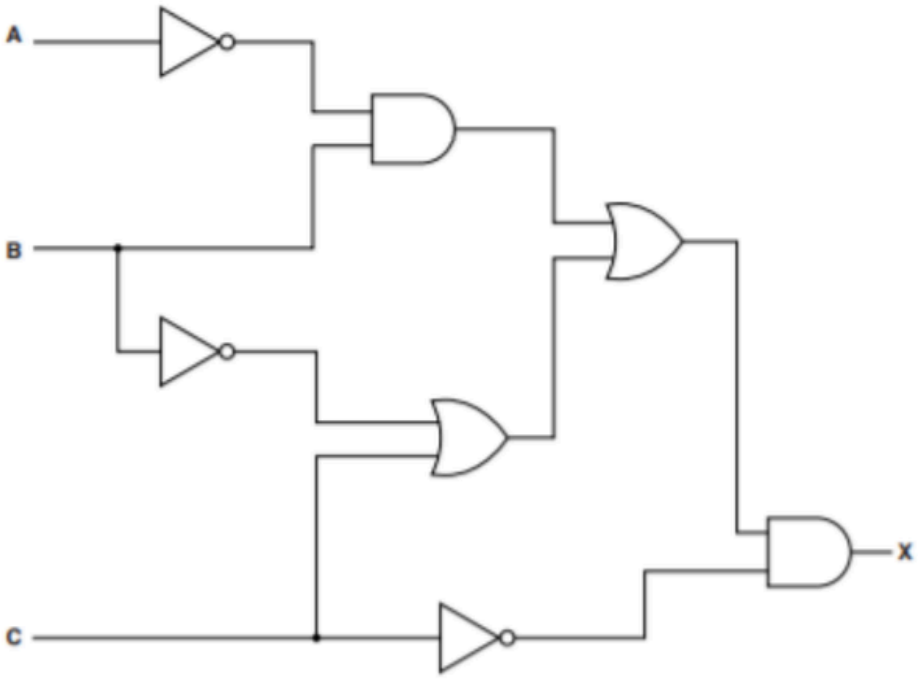
(b) Complete the truth table for the above logic statement.

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		

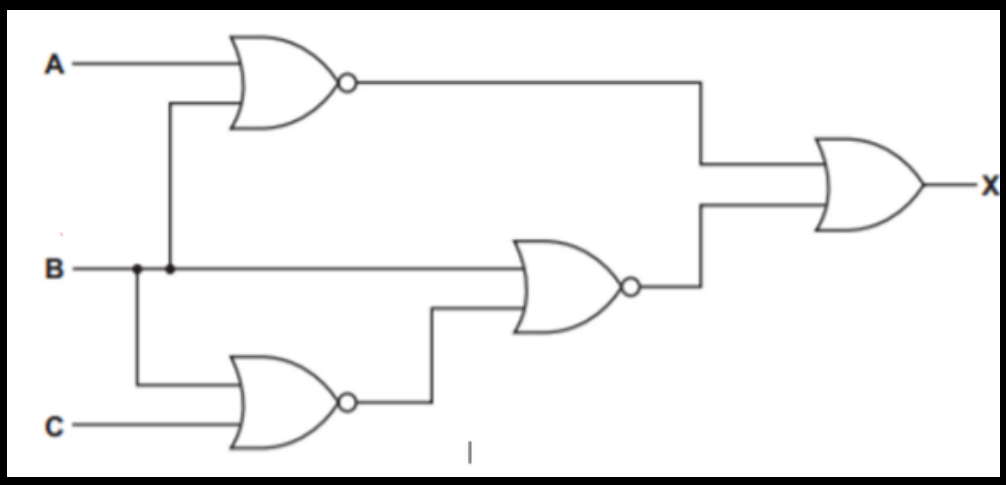
[4]

Case 3 : Construct A Logic Expression By Logic Circuit

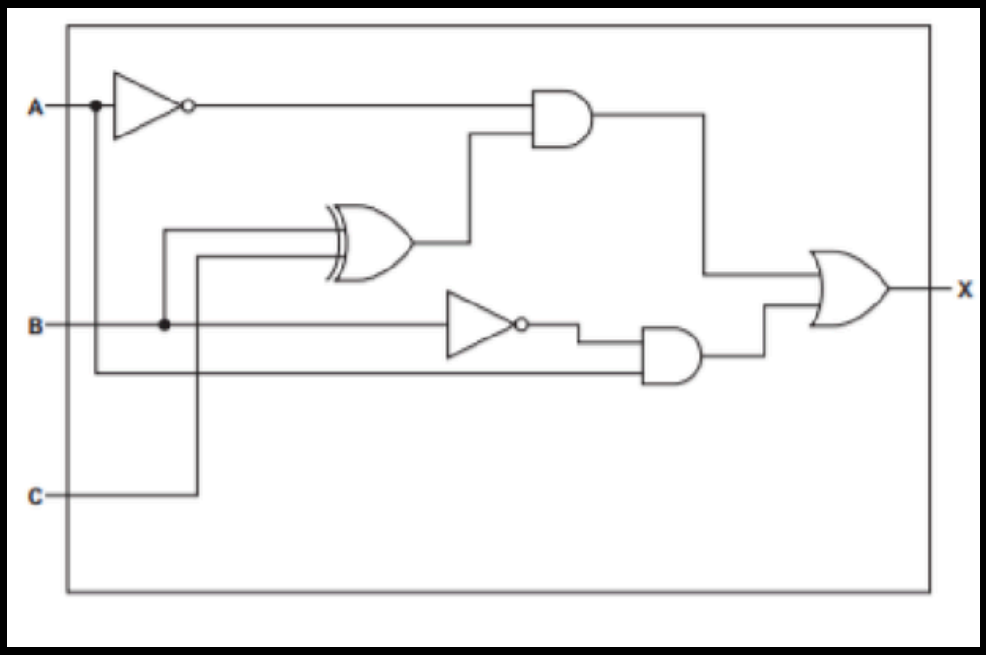
(c) Write a logic statement that describes the following logic circuit.



((NOT A AND B) OR (NOT B OR C)) AND NOT C



(A NOR B) OR (B NOR (B NOR C))



(NOT A AND (B XOR C)) OR (NOT B AND A)

Case 4 : Construct A Logic Expression By Truth Table

A = 1
A (dash) = 0 (NOT A)

Step 1 : Mark Rows With Output 1
Step 2 : Use sum of product (Inputs are getting multiplied and Rows are getting added
Step 3 : Now write A or A(dash)

3 (a) A Boolean algebraic expression produces the following truth table.

INPUT			OUTPUT
A	B	C	X
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	0
1	1	1	0

$$\left(\underset{1}{\bar{A}\cdot B\cdot\bar{C}} + \underset{2}{\bar{A}\cdot\bar{B}\cdot C} + \underset{3}{\bar{A}\cdot B\cdot\bar{C}} + \underset{4}{\bar{A}\cdot B\cdot C} + \underset{5}{A\cdot\bar{B}\cdot\bar{C}} + \underset{6}{A\cdot\bar{B}\cdot C}\right)$$

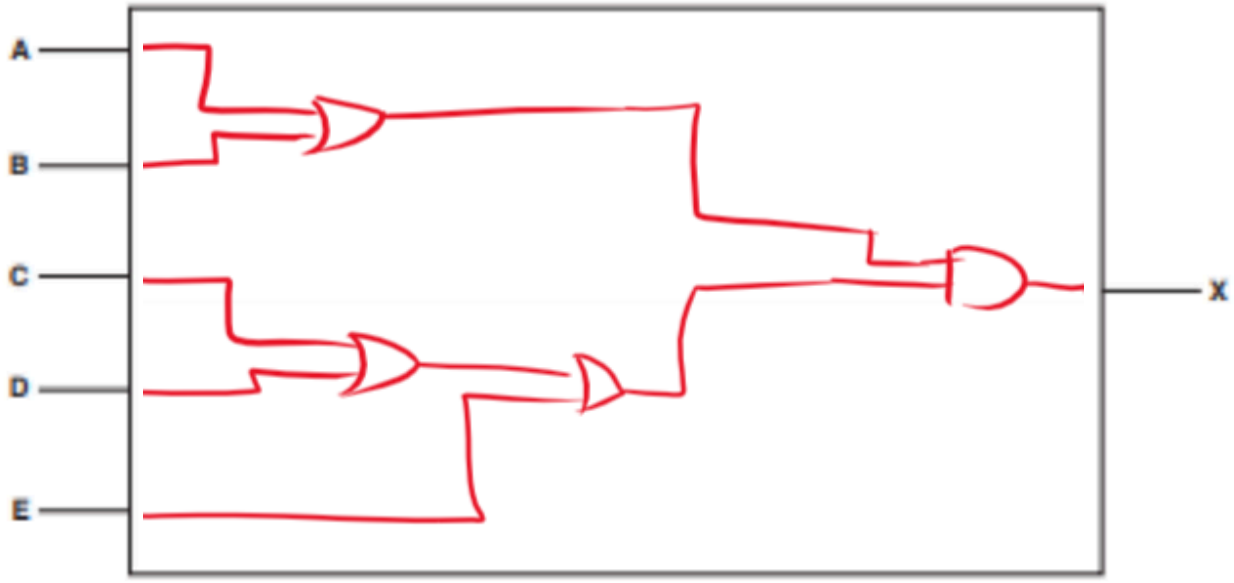
Note : Looks for patterns first because usually the questions are very simple and 1 mark only.

Case 5 : Construct A Logic Circuit By Problem Statement

4 **(a)** An alarm system (X) is enabled and disabled using either a switch (A) or a remote control (B). There are **two** infra-red sensors (C, D) and **one** door pressure sensor (E).

Parameter	Description of parameter	Binary value	Condition
A	Switch	1	Switch enabled
		0	Switch disabled
B	Remote control	1	Remote enabled
		0	Remote disabled
C	Infra-red sensor	1	Activated
		0	Not activated
D	Infra-red sensor	1	Activated
		0	Not activated
E	Door pressure sensor	1	Activated
		0	Not activated

The alarm sounds (X = 1) if the alarm is enabled **and** any one or more of the sensors is activated.
Draw a logic circuit to represent the alarm system.



[3]

Logic Gate

Question 1

8 Tick (✓) **one** box in each row to identify the logic gate that each statement describes.

Statement	AND	NAND	NOR	XOR	OR
The output is 1 only when both inputs are 1					
The output is 1 only when both inputs are different					
The output is 1 only when both inputs are 0					

[3]

Question 2

3 A logic expression is given:

S = (**A** AND **B** AND **C**) OR (**B** XOR **C**)

(a) Draw the logic circuit for the given expression.

[4]

(b) Complete the truth table for the logic expression:

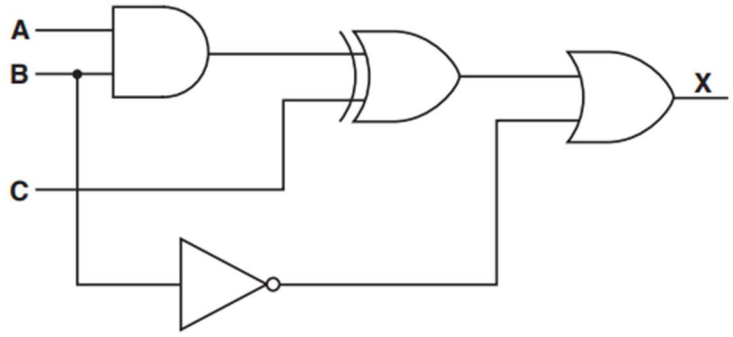
S = (**A** AND **B** AND **C**) OR (**B** XOR **C**)

A	B	C	Working space	S
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]

Question 3

3 A logic circuit is shown:



(a) Write the logic expression for the logic circuit.

.....

..... [3]

(b) Complete the truth table for the given 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]

(c) Identify **one** logic gate **not** used in the given logic circuit. Draw the symbol for the logic gate **and** complete its truth table.

Logic gate: .....

Symbol:

Truth table:

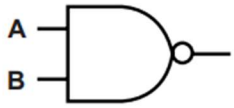
A	B	Output
0	0	
0	1	
1	0	
1	1	

[3]

Question 4

2 **(a)** Complete the truth table for each of the following two logic gates.

A	B	Output
0	0	
0	1	
1	0	
1	1	

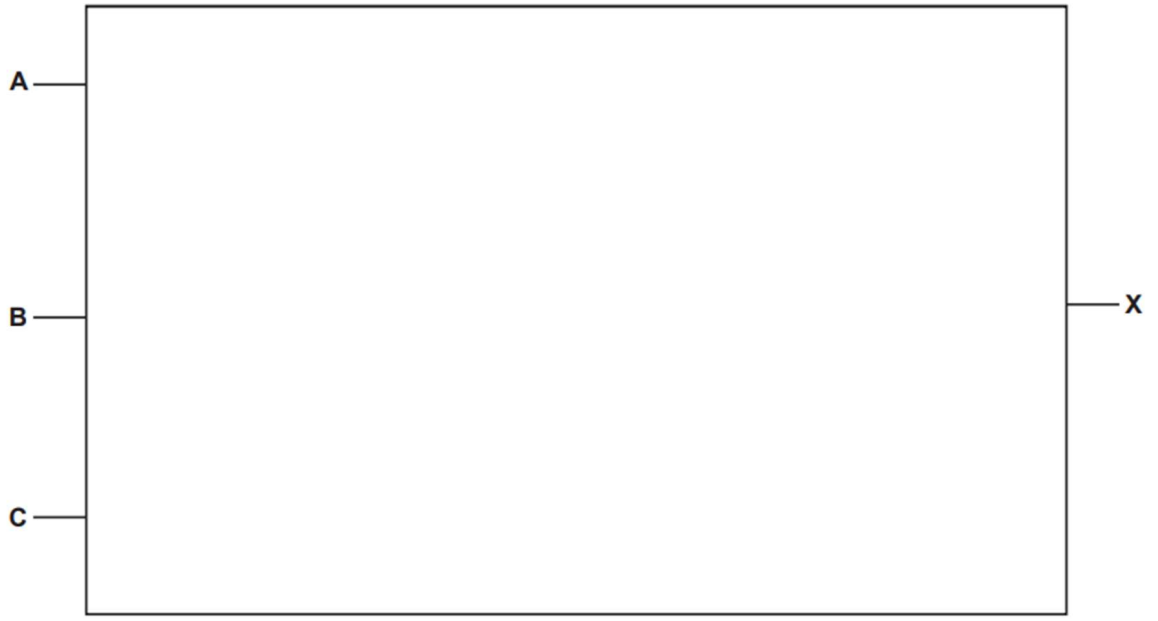


A	B	Output
0	0	
0	1	
1	0	
1	1	

[2]

(b) Draw a logic circuit for the following logic expression.

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



[2]

Question 5

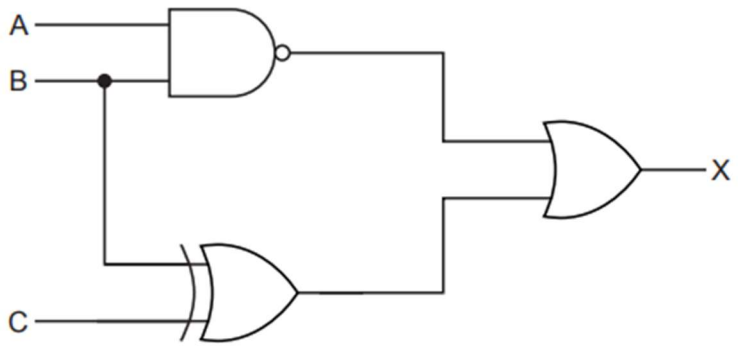
(c) Computers consist of logic gates.

(i) Complete the table by writing **one** set of values (input 1 and input 2) for each gate that will give the output 1.

Gate	Input 1	Input 2	Output
AND			1
NAND			1
XOR			1
NOR			1

[4]

(ii) Write the logic expression for the given logic circuit.



.....

.....

..... [3]

Question 6

7 Complete the truth table for the following logic expression:

X = (**A** XOR **B**) AND NOT **C**

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]

Question 7

3 **(a)** The table shows part of the instruction set for a processor. The processor has one general purpose register, the Accumulator (ACC).

Instruction		Explanation
Opcode	**Operand**	
LDM	#n	Immediate addressing. Load the number n to ACC
LDD	<address>	Direct addressing. Load the contents of the location at the given address to ACC
LDI	<address>	Indirect addressing. The address to be used is at the given address. Load the contents of this second address to ACC
<address> can be an absolute or symbolic address # denotes a denary number, e.g. #123		

The current contents of main memory are:

Address	
100	101
101	67
102	104
103	100
104	68

Complete the table by writing the value stored in the accumulator after the execution of each instruction.

Instruction	Accumulator
LDM #103	
LDD 102	
LDI 103	

[3]

(b) The instructions in **part (a)** are examples of the data movement group.

Describe **two other** instruction groups.

1 .....

.....

.....

.....

2 .....

.....

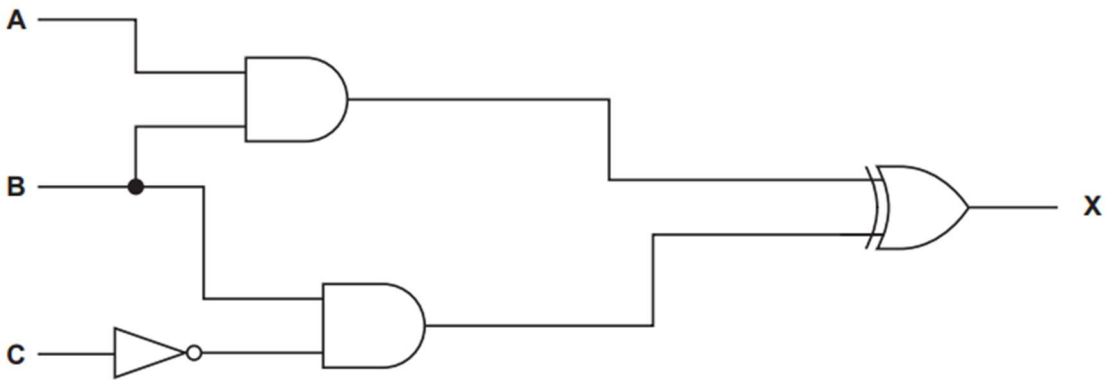
.....

.....

[4]

Question 8

7 **(a)** Write the logic expression for the following logic circuit.



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..... [3]

(b) Complete the truth table for the following logic expression:

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

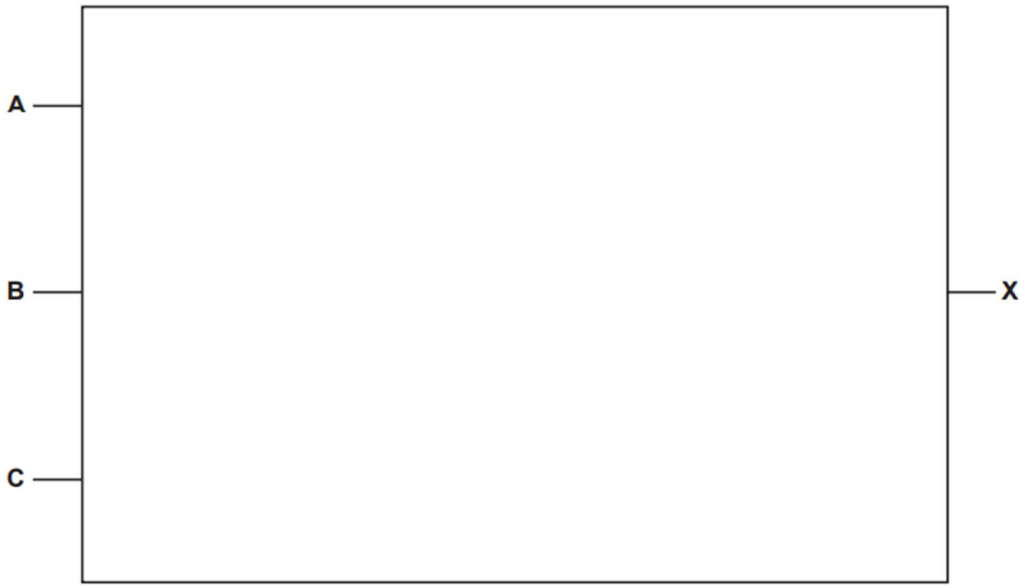
A	B	C	Working space	X
0	0	0		
0	0	1		
0	1	0		
0	1	1		
1	0	0		
1	0	1		
1	1	0		
1	1	1		

[2]

Question 9

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

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



[2]

(b) Complete the truth table for the logic expression:

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

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]

Question 10

3 (a) A greenhouse has an automatic window.

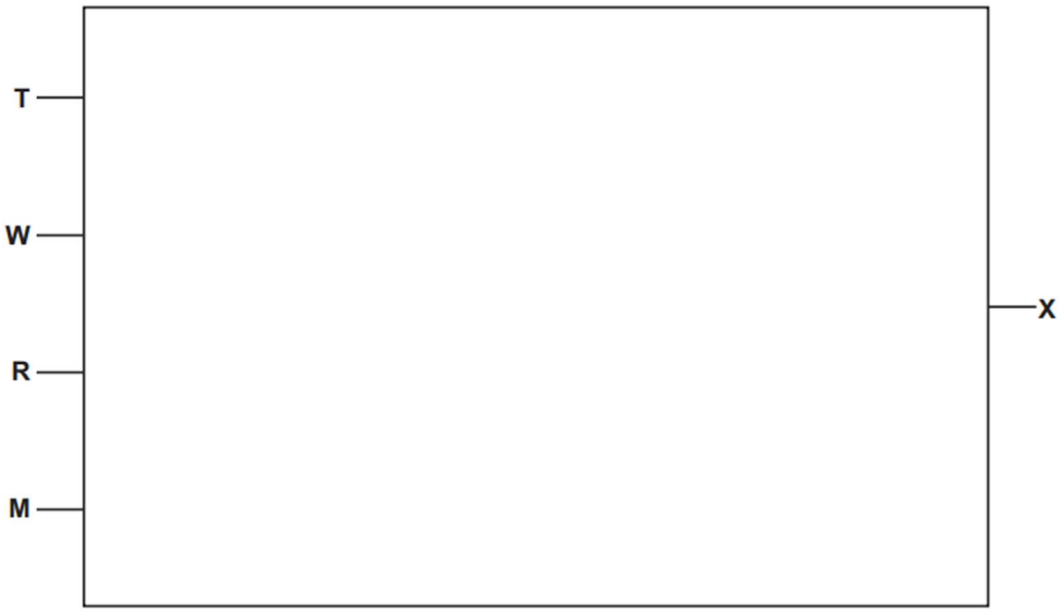
The window (**X**) operates according to the following criteria:

Parameter	Description of parameter	Binary value	Condition
T	Temperature	1	Too high
		0	Acceptable
W	Wind speed	1	Too high
		0	Acceptable
R	Rain	1	Detected
		0	Not detected
M	Manual override	1	On
		0	Off

The window opens (**X** = 1) if:

- the temperature is too high **and** the wind speed is acceptable
- **and**
- rain is not detected, **or** the manual override is off.

Draw a logic circuit to represent the operation of the window.



[3]

(b) Complete the truth table for the logic expression:

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

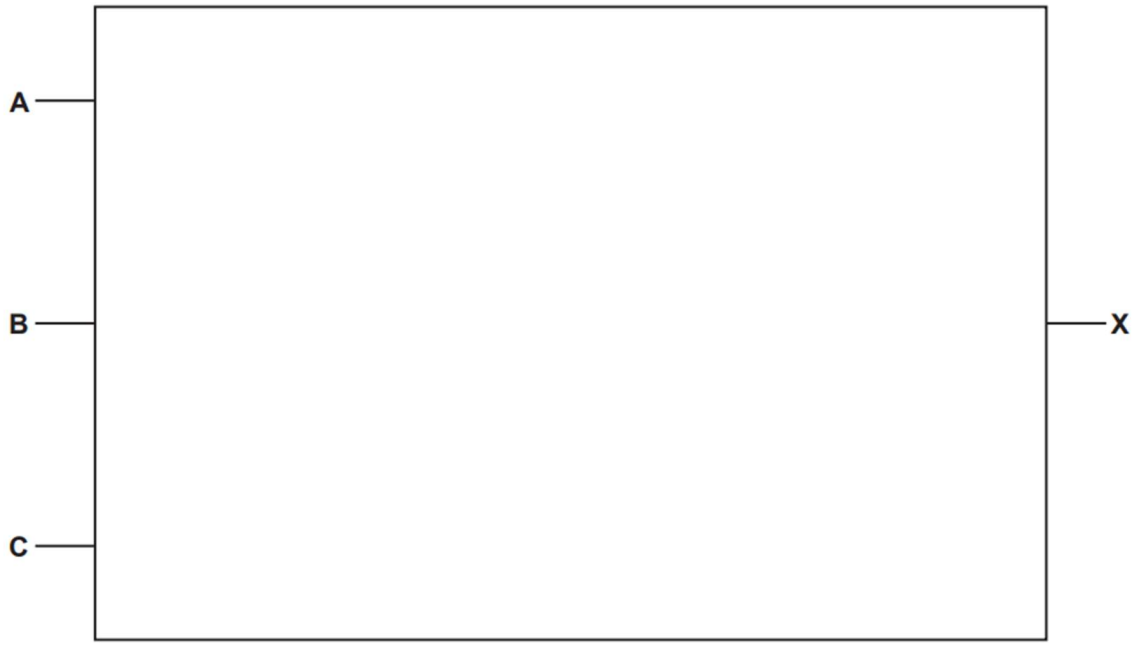
A	B	C	Working space	X
0	0	0		
0	0	1		
0	1	0		
0	1	1		
1	0	0		
1	0	1		
1	1	0		
1	1	1		

[2]

Question 11

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

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



[3]

(b) Complete the truth table for the logic expression:

Y = (NOT **P** AND **Q**) OR (**Q** AND NOT **R**)

P	Q	R	Working space	Y
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]

Question 12

5 **(a)** Draw the logic circuit for this logic expression:

T = (NOT **A** OR **B**) XOR (**C** NAND **D**)

[2]

(b) Describe the function of the NAND and NOR logic gates.

NAND .....

.....

NOR .....

.....

[2]

Question 13

6 **(a)** Draw the logic circuit for this logic expression:

Z = (**R** XOR **S**) AND (NOT **T** NOR **P**)

[2]

(b) Complete the truth table for this logic expression:

Z = (NOT **P** OR **Q**) XOR (**R** NOR **Q**)

P	Q	R	Working space	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		

[2]

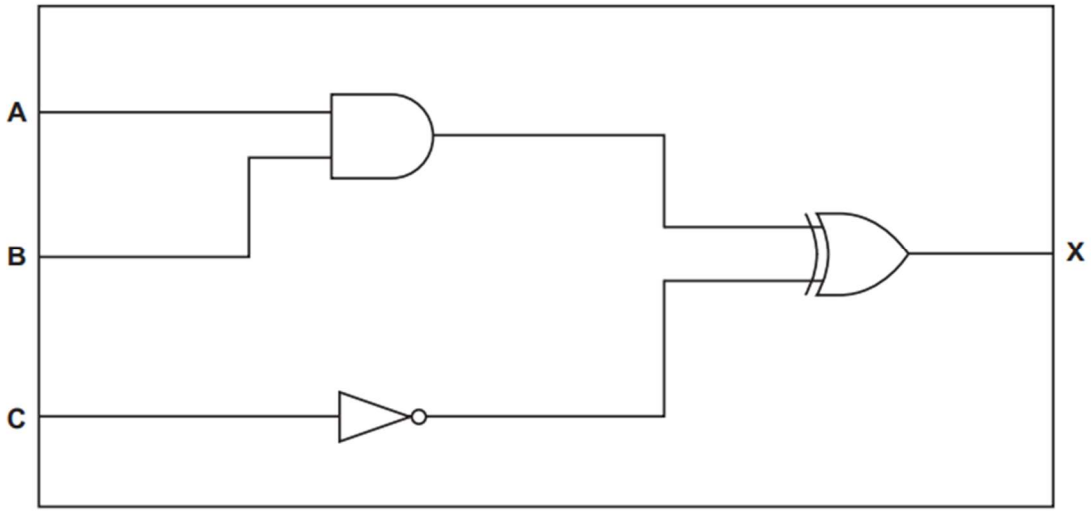
Question 14

1 **(a)** Write the logic expression for this truth table:

A	B	C	X
0	0	0	1
0	0	1	1
0	1	0	0
0	1	1	0
1	0	0	1
1	0	1	1
1	1	0	0
1	1	1	0

..... [1]

(b) Complete the truth table for this 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]

Question 15

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

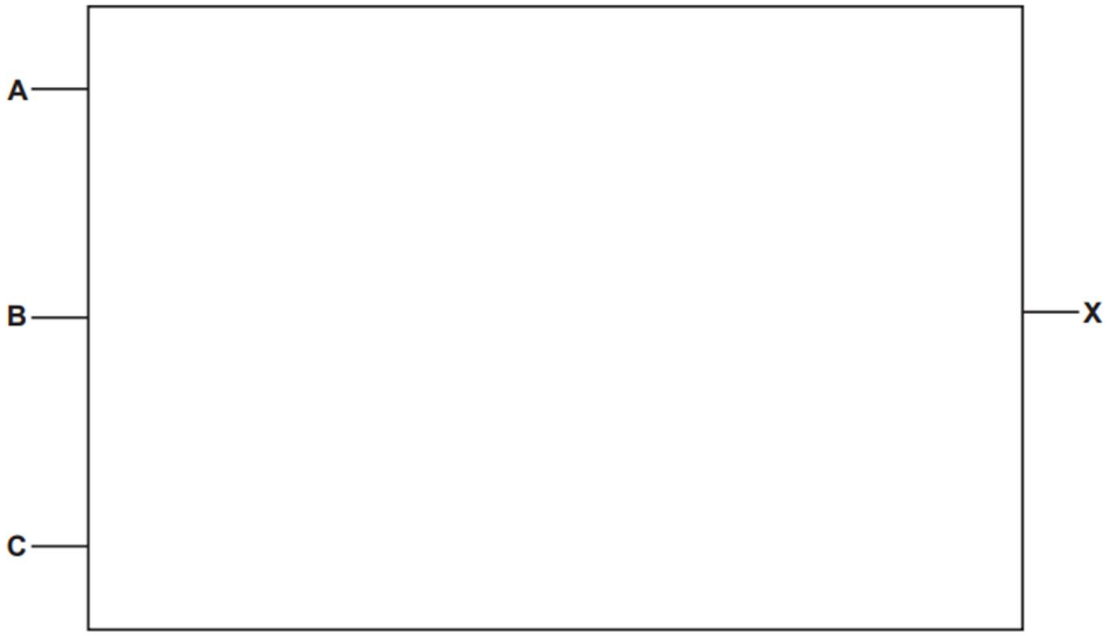
X = NOT (**A** NAND **B**) XOR (NOT **B** AND (**B** NOR **C**))

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:

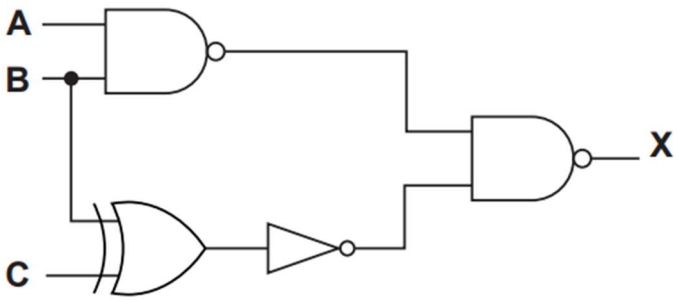
X = (**A** AND NOT (**B** OR **C**)) AND (**B** NOR **C**)



[2]

Question 16

4 **(a)** Write the Boolean expression that corresponds to the following logic circuit.



.....

..... [3]

(b) Complete the truth table for the logic expression:

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

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]

Question 17

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

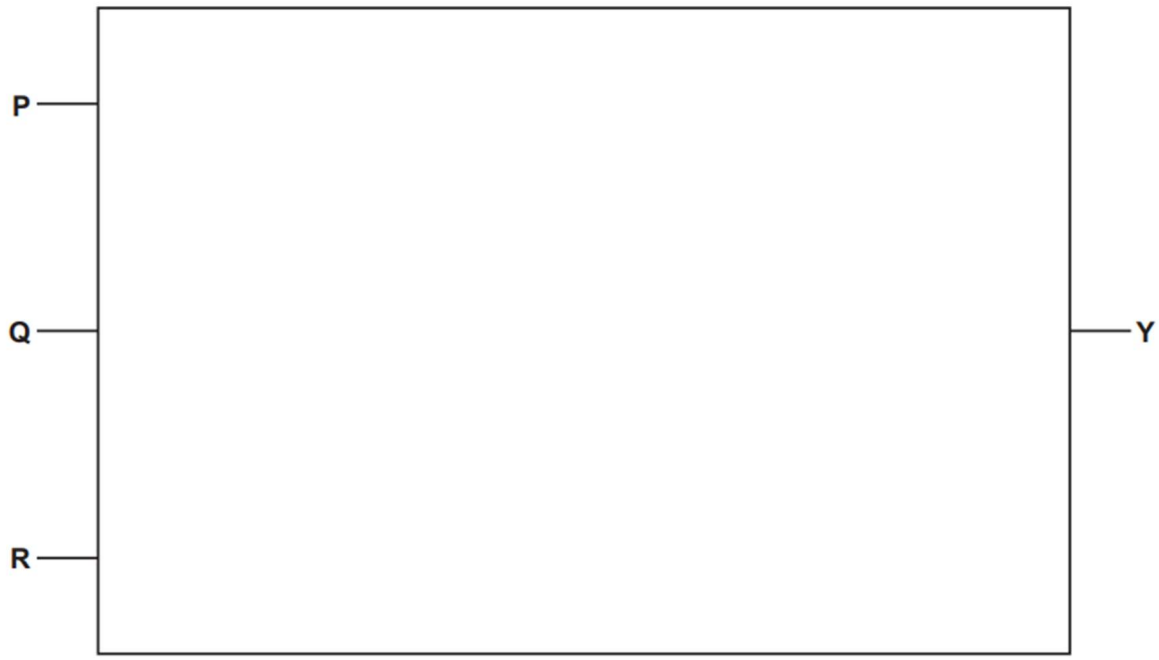
Y = ((**P** AND **Q**) XOR ((NOT **Q**) OR **R**)) AND NOT **P**

P	Q	R	Working space	Y
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:

Y = ((**P** AND **Q**) XOR ((NOT **Q**) OR **R**)) AND NOT **P**



[2]

Question 18

1 **(a)** Tick (✓) **one** box to identify the correct logic statement for this truth table.

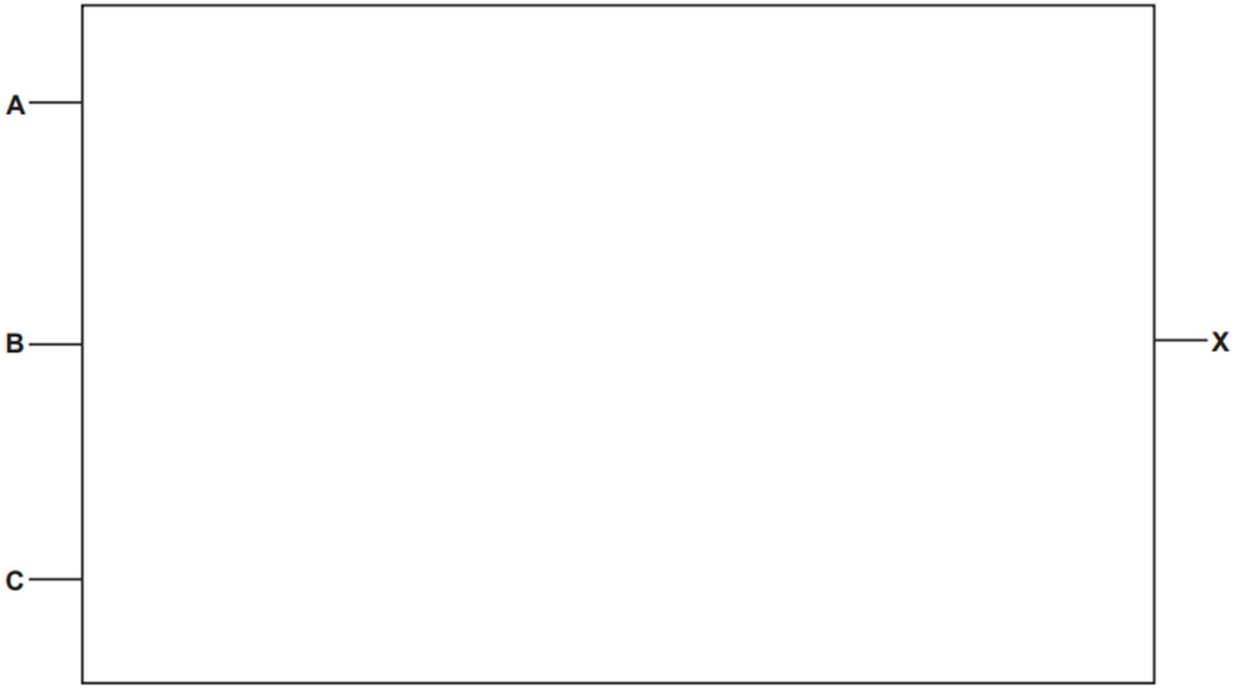
A	B	C	X
0	0	0	1
0	0	1	0
0	1	0	0
0	1	1	0
1	0	0	0
1	0	1	0
1	1	0	1
1	1	1	0

- ☐ NOT (**A** AND **B** AND **C**)
- ☐ (**A** XOR **B**) NOR **C**
- ☐ (**A** OR **B** OR **C**) NOR **C**
- ☐ NOT **A** AND NOT **B** AND NOT **C**

[1]

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

X = NOT (NOT **A** AND (NOT **B** XOR **C**))



[2]

Question 19

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

NAND .....

.....

NOR .....

.....

XOR .....

.....

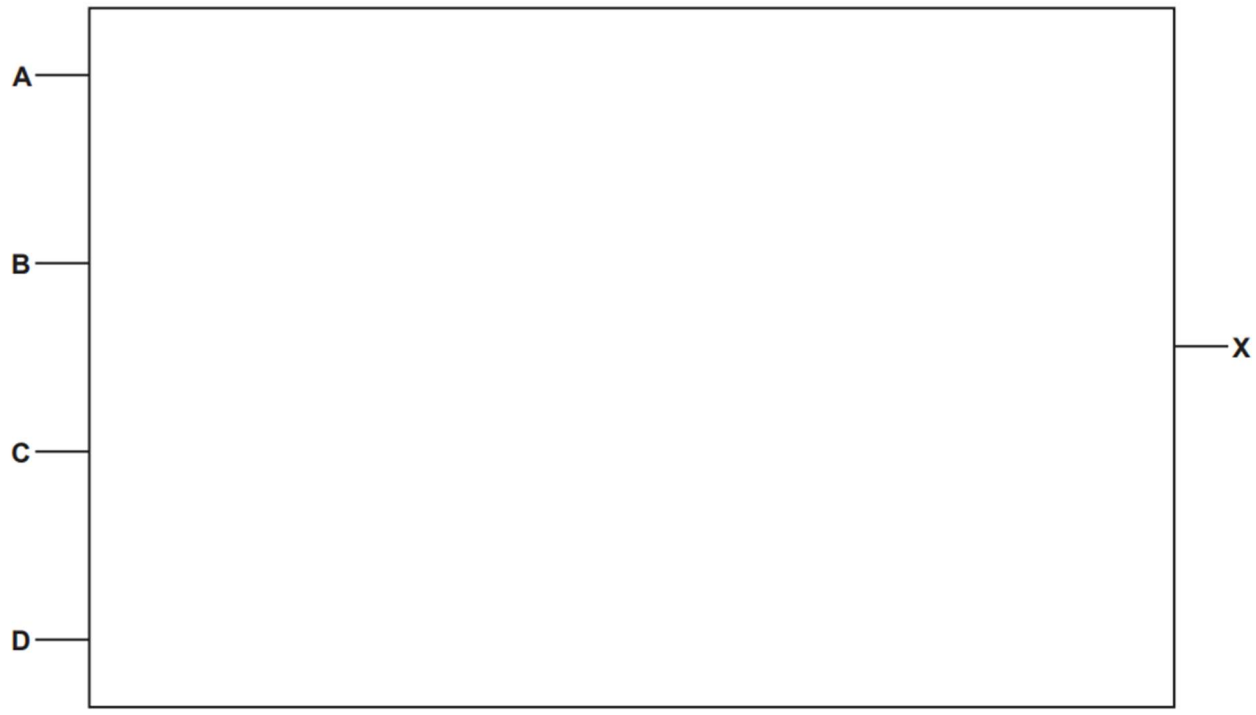
OR .....

.....

[4]

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

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



[2]

Question 20

6 Each of the following truth tables has three inputs (**A**, **B** and **C**) and one output (**X**).

Draw **one** line to match each truth table with its logic expression.

Truth table

A	B	C	X
0	0	0	0
0	0	1	1
0	1	0	0
0	1	1	0
1	0	0	1
1	0	1	1
1	1	0	0
1	1	1	0

A	B	C	X
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	0
1	1	1	1

A	B	C	X
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	0
1	1	1	1

Logic expression

NOT (**A** XOR **B**) AND **C**

(**A** OR **C**) AND NOT **B**

A NAND **B** NAND **C**

(**A** NAND **B**) OR **C**

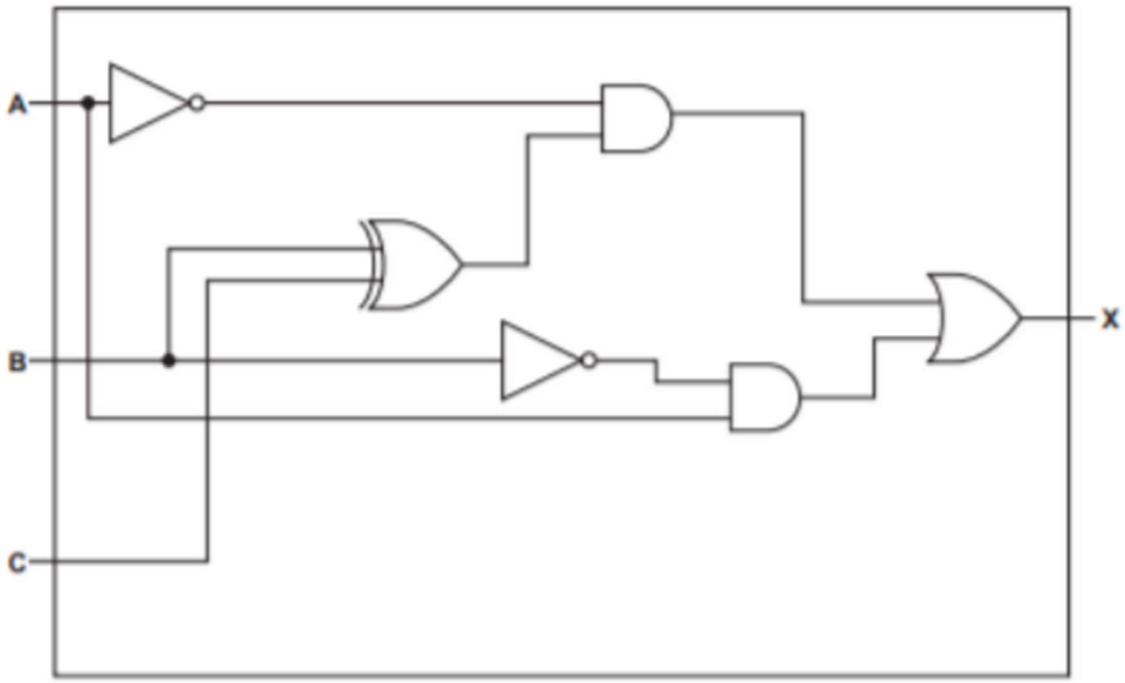
NOT (**A** AND **B** AND **C**)

[3]

9608 Topical Past Paper

Question 21

5 (a) A logic circuit is given:



Complete the following truth table for the 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		

[4]

(b) Identify **one** logic gate not used in the logic circuit in **part (a)**.

Draw the symbol for this logic gate **and** complete its truth table.

Logic gate: .....

Symbol:

Truth table:

Input		Output
A	B	
0	0	
0	1	
1	0	
1	1	

[3]

Question 22

3 The following is a logic expression.

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

Draw the logic circuit for the given expression using a maximum of **four** gates.

[4]

Question 23

3 **(a)** The following is a logic expression.

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

Draw the logic circuit for the given expression, using a maximum of **four** logic gates.

[4]

(b) Complete the truth table for the logic expression:

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

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		

[4]

(c) The following is a logic expression.

A AND **B** XOR **C** OR NOT **A**

Identify **one** logic gate that would **not** be used in the logic circuit for this expression.
Draw the symbol for the logic gate.

Logic gate .....

Logic gate symbol:

Question 24

6 **(a)** Draw a logic circuit to represent the logic expression:

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

[5]

(b) Complete the truth table for the logic expression in **part (a)**.

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		

[4]

Question 25

3 (a) A bank approves a customer for an account based on the criteria in the following table.

Parameter	Description of parameter	Binary value	Condition
A	Employed	1	True
		0	False
B	Self-employed	1	True
		0	False
C	Over 21	1	True
		0	False
D	Earn more than 30 000	1	True
		0	False
E	Another account	1	True
		0	False

A customer is approved (**X** = 1) if the person:

- is over 21 **and** employed
  or
- is over 21 **and** self-employed **and**
  - **either** earns more than 30 000
    or
  - has another account.

Draw a logic circuit to represent the model.

[5]

(b) Complete the truth table for the logic expression:

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

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		

[4]

Question 26

2 **(a)** Draw a logic circuit to represent the following logic expression:

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

[4]

(b) Complete the truth table for the logic expression:

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

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		

[4]

Question 27

5 **(a)** Draw a logic circuit to represent the logic expression:

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

[5]

(b) Complete the truth table for the logic expression:

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

[4]

Question 28

4 **(a)** An alarm system (X) is enabled and disabled using either a switch (A) or a remote control (B). There are **two** infra-red sensors (C, D) and **one** door pressure sensor (E).

Parameter	Description of parameter	Binary value	Condition
A	Switch	1	Switch enabled
		0	Switch disabled
B	Remote control	1	Remote enabled
		0	Remote disabled
C	Infra-red sensor	1	Activated
		0	Not activated
D	Infra-red sensor	1	Activated
		0	Not activated
E	Door pressure sensor	1	Activated
		0	Not activated

The alarm sounds (X = 1) if the alarm is enabled **and** any one or more of the sensors is activated.

Draw a logic circuit to represent the alarm system.

[3]

(b) Complete the truth table for the logic expression: **X** = **A** OR (**B** XOR **C**)

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		

[4]

Question 29

2 (a) A greenhouse control system has four input parameters (H, D, T, W) and two outputs (X, Y).

Parameter	Description of parameter	Binary value	Condition
H	Humidity	0	Too low
		1	Acceptable
D	Day	0	Night
		1	Day
T	Temperature	0	Too high
		1	Acceptable
W	Windows	0	Closed
		1	Open

The watering system turns on (X = 1) if:

either it is daytime **and** the temperature is too high

or the humidity is too low.

The fan turns on (Y = 1) if the temperature is too high **and** the windows are closed.

Draw a logic circuit to represent the greenhouse control system.

[6]

(b) Complete the truth table for the logic expression: **X** = NOT **A** AND (**B** NAND **C**)

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		

[4]

Question 30

5 **(a)** A student needs to design a logic circuit to model the requirements for membership of a snooker club. Membership (X) depends on four criteria, as shown in the table:

Parameter	Description of parameter	Binary value	Condition
A	Over 18	1	True
		0	False
B	Recommended	1	True
		0	False
C	Full-time	1	True
		0	False
D	Retired	1	True
		0	False

Membership is approved (X = 1) if the person:

- is over the age of 18 **and** has been recommended by a pre-existing member **and**
- **either** is working full-time **or** is retired, but not both.

Draw a logic circuit to represent the membership requirements.

[3]

(b) Complete the truth table for the logic expression: **X** = (**A** XOR **B**) AND NOT **C**

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		

[4]

Question 31

8 (a) Draw a logic circuit to represent the logic expression:

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

[4]

(b) Complete the truth table for the logic expression in **part (a)**.

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		

[4]

Question 32

5 A motor is controlled by a logic circuit. The circuit has inputs (0 or 1) from three sensors R, T and W. The motor is switched off when the output from the logic circuit is 1.

The following table shows the three sensors and the conditions being monitored.

Sensor	Description	Binary value	Condition
R	rotation	0	rotation < 4000 rpm
		1	rotation >= 4000 rpm
T	temperature	0	temperature >= 90 °C
		1	temperature < 90 °C
W	water flow rate	0	water flow rate >= 50 litre/min
		1	water flow rate < 50 litre/min

The output, X, is 1 if:

temperature >= 90 °C and rotation >= 4000 rpm

or

temperature < 90 °C and water flow rate >= 50 litre/min

(i) Draw a corresponding logic circuit.

[5]

(ii) Give a logic statement corresponding to the logic circuit in part (i).

.....

.....[2]

(iii) Complete the truth table for this system.

INPUT			Workspace	OUTPUT
R	T	W		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		

[4]

Question 33

1 **(a)** A student writes the following logic expression:

X is 1 IF (B is NOT 1 AND S is NOT 1) OR (P is NOT 1 AND S is 1)

Draw a logic circuit to represent this logic expression.

Do not attempt to simplify the logic expression.

[6]

(b) Complete the truth table for the logic expression given in **part (a)**.

B	S	P	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		

[4]

Question 34

5 A motor is controlled by a logic circuit. The circuit has inputs (0 or 1) from three sensors R, T and W. The motor is switched off when the output from the logic circuit is 1.

The following table shows the three sensors and the conditions being monitored.

Sensor	Description	Binary value	Condition
R	rotation	0	rotation < 4000 rpm
		1	rotation >= 4000 rpm
T	temperature	0	temperature >= 90 °C
		1	temperature < 90 °C
W	water flow rate	0	water flow rate >= 50 litre/min
		1	water flow rate < 50 litre/min

The output, X, is 1 if:

temperature >= 90 °C and rotation >= 4000 rpm

or

temperature < 90 °C and water flow rate >= 50 litre/min

(i) Draw a corresponding logic circuit.

[5]

(ii) Give a logic statement corresponding to the logic circuit in part (i).

.....

.....[2]

(iii) Complete the truth table for this system.

INPUT			Workspace	OUTPUT
R	T	W		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		

[4]

Question 35

7 A system is monitored using sensors. The sensors output binary values corresponding to physical conditions, as shown in the table:

Parameter	Description of parameter	Binary value	Description of condition
P	oil pressure	1	pressure >= 3 bar
		0	pressure < 3 bar
T	temperature	1	temperature >= 200°C
		0	temperature < 200°C
R	rotation	1	rotation <= 1000 revs per minute (rpm)
		0	rotation > 1000 revs per minute (rpm)

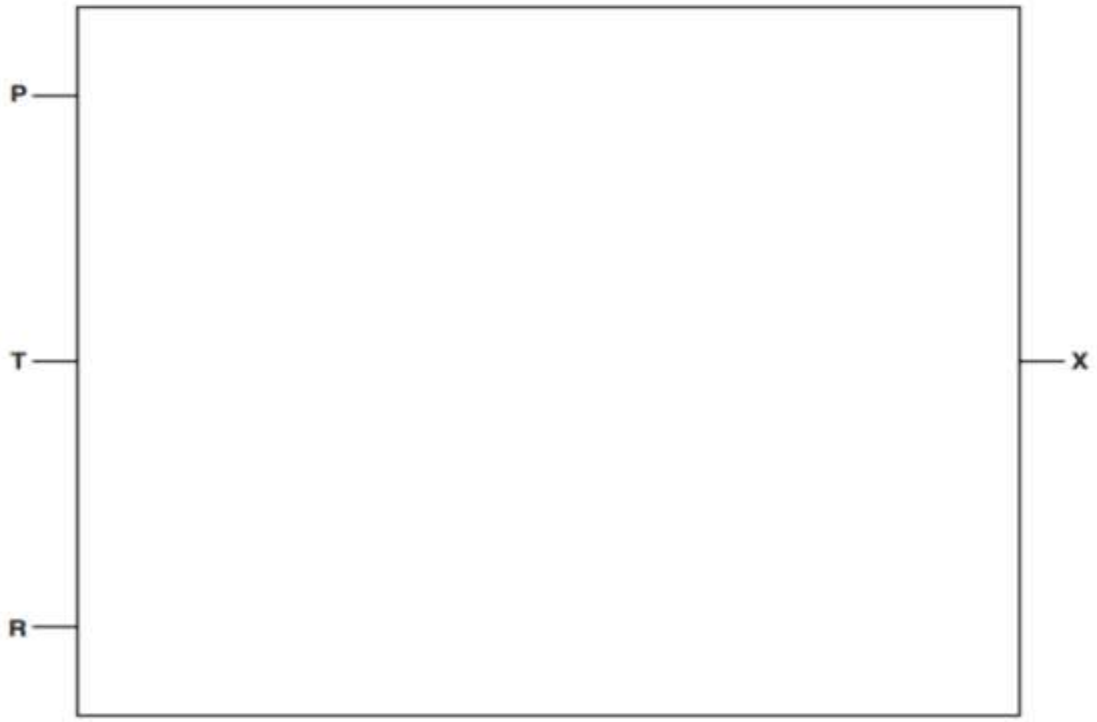
The outputs of the sensors form the inputs to a logic circuit. The output from the circuit, X, is 1 if any of the following three conditions occur:

either oil pressure >= 3 bar **and** temperature >= 200°C

or oil pressure < 3 bar **and** rotation > 1000 rpm

or temperature >= 200°C **and** rotation > 1000 rpm

(a) Draw a logic circuit to represent the above system.



[5]

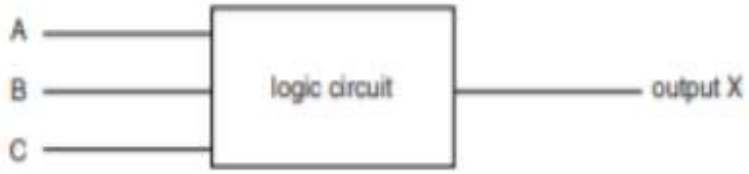
(b) Complete the truth table for this system.

P	T	R	Workspace	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		

[4]

Question 36

6 (a) Three digital sensors A, B and C are used to monitor a process. The outputs from the sensors are used as the inputs to a logic circuit.



Output, X, has a value of 1 if either of the following two conditions occur:

- sensor A outputs the value 1 OR sensor B outputs the value 0
- sensor B outputs the value 1 AND sensor C outputs the value 0

Draw a logic circuit to represent these conditions.

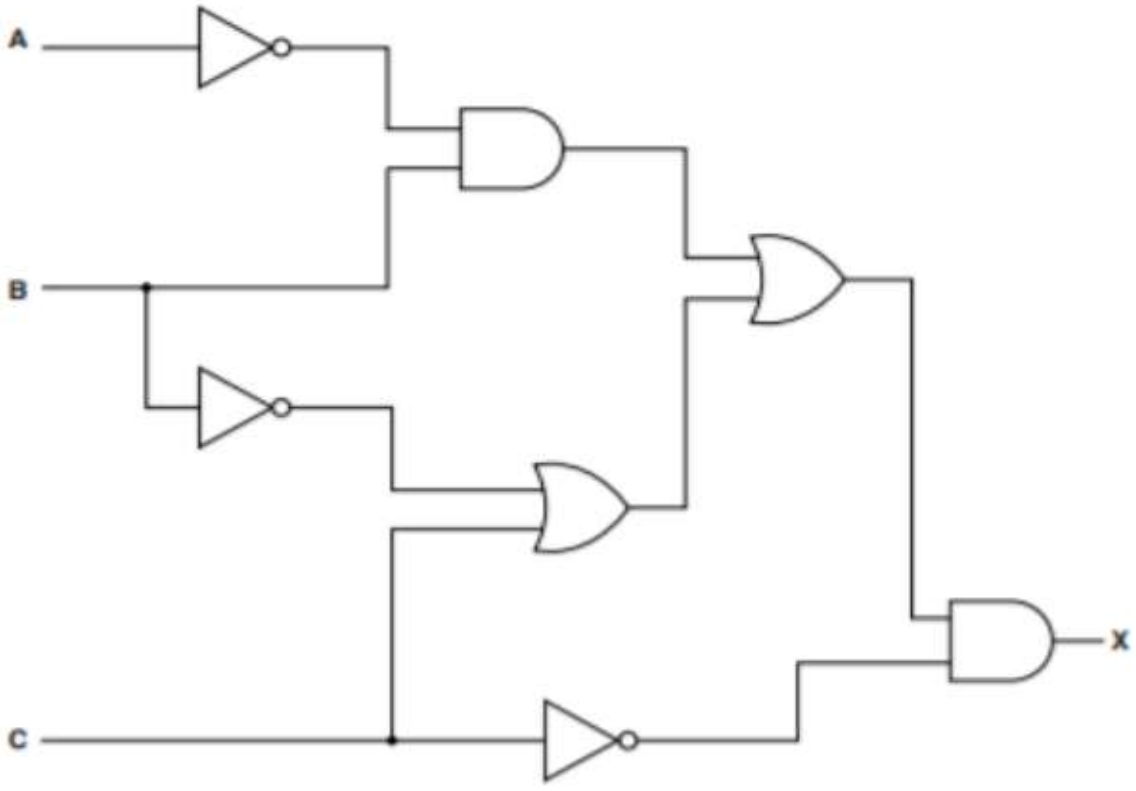
[5]

(b) Complete the truth table for the logic circuit described in **part (a)**.

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		

[5]

(c) Write a logic statement that describes the following logic circuit.



Question 37

6 **(a)** A student wrote the following logic statement:

X is 1 if (B is NOT 1 AND S is NOT 1) OR (P is NOT 1 AND S is 1)

Draw a logic circuit to represent the above logic statement.

[6]

(b) Complete the truth table for this system.

B	S	P	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		

[4]

Question 38

8 A car has an engine management system (EMS). The EMS outputs the following signals.

signal	value	description
A	0	temperature within limits
	1	temperature too high (fault condition)
B	0	pressure within limits
	1	pressure too high (fault condition)
C	0	carbon emissions within limits
	1	carbon emissions too high (fault condition)

(a) (i) Draw a logic circuit for the following fault condition:

All three signals (A = 1, B = 1 and C = 1) indicate a fault. The driver is warned to stop the engine – output X = 1.

[2]

(ii) Draw a logic circuit for the fault condition:

Either (A = 1 and B = 1) or (B = 1 and C = 1) indicate a fault. The driver is warned that the engine needs a service – output Y = 1.

[2]

(iii) Draw a logic circuit for the fault condition:

Either A = 1 or B = 1 or C = 1 indicate a fault. A red warning light shows up on the dashboard – output Z = 1.

[2]

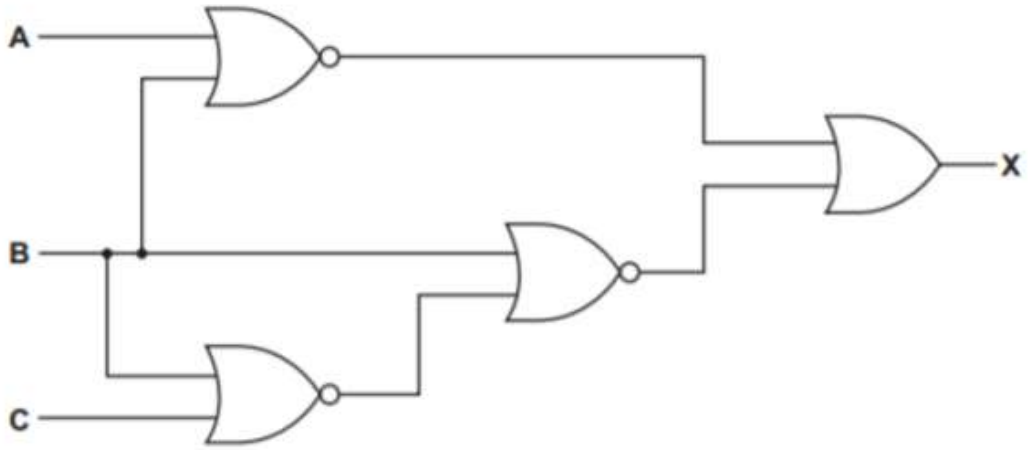
(b) Complete the truth table for the three fault conditions:

A	B	C	working	X	Y	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				

[6]

Question 39

8 **(a)** Complete the truth table for the following logic circuit:



A	B	C	working	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		

[4]

(b) Draw a logic circuit corresponding to the following logic statement:

X = 1 if (A = **NOT** 1 **OR** B = 1) **AND** (B = **NOT** 1 **AND** C = **NOT** 1)

[6]

Question 40

6 A wind turbine must shut down when certain conditions are met.

The three variables and the conditions which dictate their values are shown in the table:

variable		binary value	condition
name	**description**		
W	wind speed	1	wind speed ⩾ 100 kilometres per hour (kph)
		0	wind speed < 100 kilometres per hour (kph)
P	oil pressure	1	oil pressure **low**
		0	oil pressure **normal**
T	motor temperature	1	motor temperature ⩾ 50 °C
		0	motor temperature < 50 °C

A logic circuit is to be designed where the output, **X**, is 1 if:

either wind speed ⩾ 100 kph and oil pressure normal

or motor temperature ⩾ 50°C and oil pressure low

or wind speed < 100 kph and motor temperature ⩾ 50°C

(a) Draw a logic circuit.

[7]

(b) Complete the truth table for this system:

W	P	T	working	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		

[4]

Question 41

9 **(a)** Draw the logic circuit corresponding to the following logic statement:

X = 1 IF (A is 1 AND B is 1) OR (B is 1 OR C is NOT 1)

[4]

(b) Complete the truth table for the above logic statement:

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		

[4]

Question 42

4 **(a)** Draw the logic circuit that directly corresponds to the following logic statement:

X = 1 IF (A is NOT 1 OR B is 1) AND (B is 1 OR C is 1)

[4]

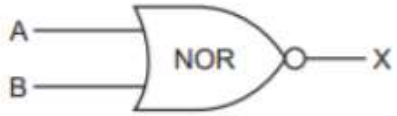
(b) Complete the truth table for the above logic statement.

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		

[4]

Question 43

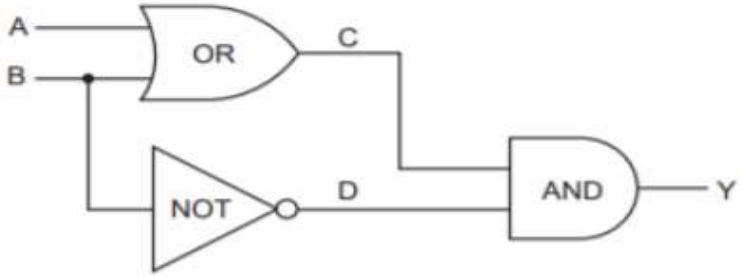
9 **(a)** Complete the truth table to show the output from the logic gate shown.



A	B	X
0	0	
0	1	
1	0	
1	1	

[2]

(b) Complete the truth table to show the outputs from the logic circuit shown.



A	B	C	D	Y
0	0			
0	1			
1	0			
1	1			

[4]

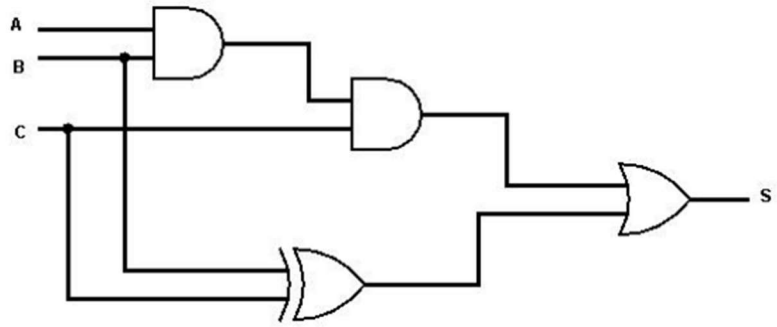
Answer

Answer 1

8	**1 mark** per correct row	3

Statement	AND	NAND	NOR	XOR	OR
The output is 1 only when both inputs are 1	✓				
The output is 1 only when both inputs are different				✓	
The output is 1 only when both inputs are 0			✓		

Answer 2

3(a)	**1 mark** for each correct gate, with correct inputs 	4
3(b)	**1 mark** for each half (shaded)	2

A	B	C	Working space	S
0	0	0		0
0	0	1		1
0	1	0		1
0	1	1		0
1	0	0		0
1	0	1		1
1	1	0		1
1	1	1		1

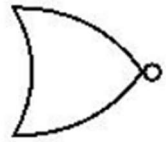
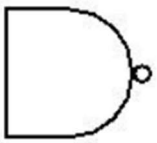
Answer 3

<table>
<tr><td>3(a)</td><td>1 mark per bullet point

• A AND B …
• … XOR C …
• … OR NOT B

((A AND B) XOR C) OR NOT B</td><td>3</td></tr>
<tr><td>3(b)</td><td>1 mark for each set of 4 rows (shaded)

<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>1</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>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>1</td></tr>
<tr><td>1</td><td>1</td><td>1</td><td></td><td>0</td></tr>
</table>
</td><td>2</td></tr>
</table>

3(c)	**1 mark** for gate, **1 mark** for matching symbol, **1 mark** for matching truth table NOR  NAND 	**3**

A	B	OUTPUT
0	0	1
0	1	0
1	0	0
1	1	0

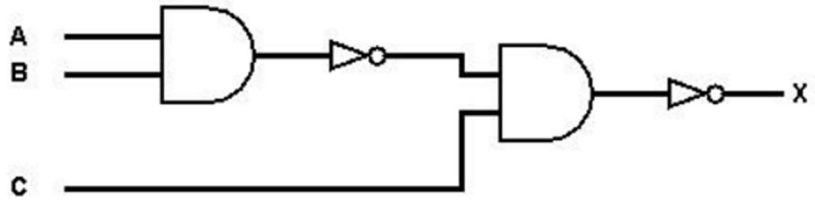
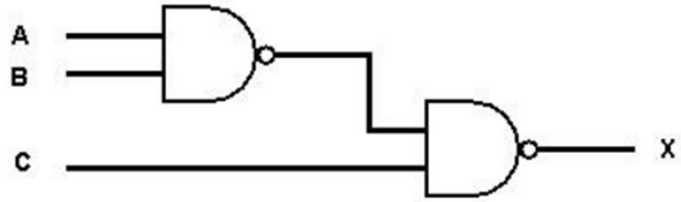
A	B	OUTPUT
0	0	1
0	1	1
1	0	1
1	1	0

Answer 4

2(a)	**1 mark** for each completely correct truth table **NOR** **NAND**	**2**

A	B	Output
0	0	1
0	1	0
1	0	0
1	1	0

A	B	Output
0	0	1
0	1	1
1	0	1
1	1	0

2(b)	**1 mark** for each correct bullet point • NOT (A AND B) // A NAND B • NOT the result AND C // the result NAND C  OR 	**2**

Answer 5

2(c)(i)	**1 mark** for each correct row. **Gate** | **Input 1** | **Input 2** **AND** | 1 | 1 **NAND** | 0 0 1 | 0 1 0 **XOR** | 0 1 | 1 0 **NOR** | 0 | 0	**4**
2(c)(ii)	**1 mark** per bullet point • **A** NAND **B** • **B** XOR **C** • OR (**A** NAND **B**) OR (**B** XOR **C**)	**3**

Answer 6

7	**1 mark** for first 4 rows, **1 mark** for second 4 rows (shaded)	**2**

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

Answer 7

3(a)	1 mark for each correct value	**3**

Instruction	Accumulator
`LDM #103`	103
`LDD 102`	104
`LDI 103`	101

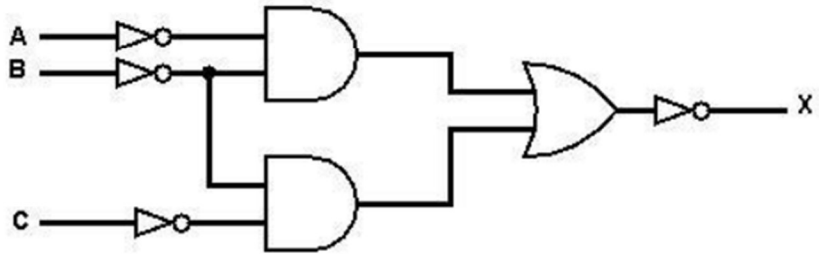
3(b)	**1 mark** for group name, **1 mark** for appropriate description e.g. • Input and output of data • Takes an input from the user // outputs the character of the binary number • Arithmetic operations • Perform addition and subtraction • Unconditional and conditional instructions • Move to another instruction (identified by a label) • Compare instructions • Compare the result to another value	**4**

Answer 8

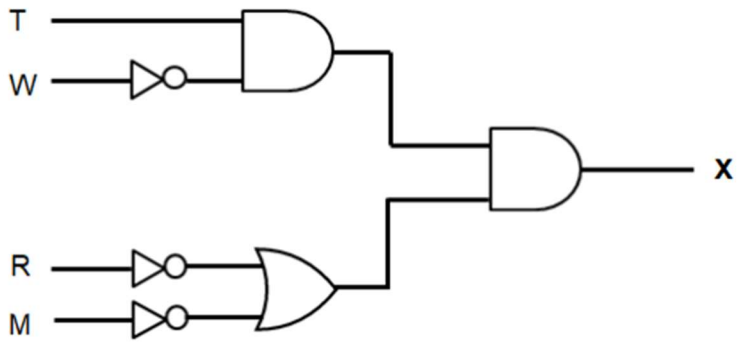
<table>
<tr>
<td>7(a)</td>
<td>
1 mark for each section
• A AND B
• NOT C AND B // B AND NOT C
• XOR (with remainder correct and bracketed and nothing extra)

X = (A AND B) XOR (NOT C AND B)
</td>
<td>3</td>
</tr>
<tr>
<td>7(b)</td>
<td>
1 mark for first 4 rows, 1 mark for second 4 rows (shaded)
<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>1</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>1</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>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>1</td></tr>
<tr><td>1</td><td>1</td><td>1</td><td></td><td>0</td></tr>
</table>
</td>
<td>2</td>
</tr>
</table>

Answer 9

3(a)	**1 mark** for each bullet point: • NOT A AND NOT B **and** NOT B AND NOT C // A NOR B **and** B NOR C • final OR and NOT gates (with correct inputs) // NOR gate (with correct inputs)  	**2**
3(b)	**1 mark** for each set of rows as highlighted: **A** **B** **C** **X** 0 0 0 0 0 0 1 0 0 1 0 1 0 1 1 1 1 0 0 0 1 0 1 1 1 1 0 1 1 1 1 1	**2**

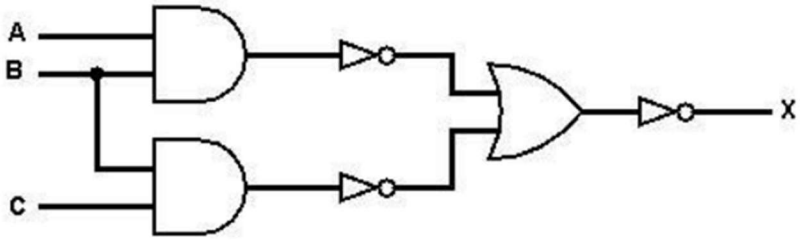
Answer 10

3(a)	**1 mark** for T AND NOT W **1 mark** for NOT R OR NOT M **1 mark** for final AND 	**3**
3(b)	**1 mark** for each set of rows as highlighted: **A** **B** **C** **X** 0 0 0 1 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 0	**2**

Answer 11

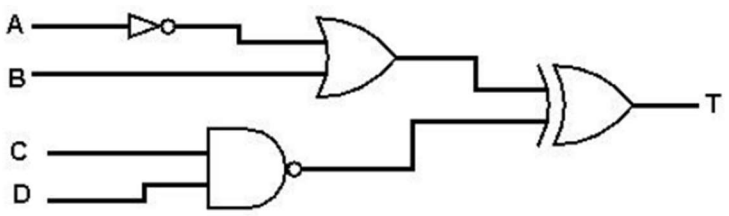
<table>
<tr>
<td>5(a)</td>
<td>
1 mark for each bullet point:

NOT (A AND B)
NOT (B AND C)
NOT(NOT(A AND B) OR NOT(B AND C))

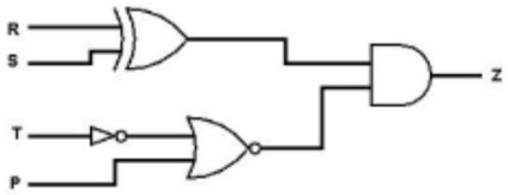


</td>
<td>3</td>
</tr>
<tr>
<td>5(b)</td>
<td>
1 mark for each set of highlighted rows.
<table>
<tr><th>P</th><th>Q</th><th>R</th><th>Y</th></tr>
<tr><td>0</td><td>0</td><td>0</td><td>0</td></tr>
<tr><td>0</td><td>0</td><td>1</td><td>0</td></tr>
<tr><td>0</td><td>1</td><td>0</td><td>1</td></tr>
<tr><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>0</td></tr>
</table>
</td>
<td>2</td>
</tr>
</table>

Answer 12

5(a)	**1 mark** for 2 gates **2 marks** for all 4 gates 	**2**
5(b)	**1 mark** each NAND 0 is **only** output when both inputs are 1 // 1 is **only** output when none, or (either) one of the inputs is 1 NOR 1 is **only** output when both inputs are 0 // 0 is **only** output when (either) one or both inputs are 1	**2**

Answer 13

6(a)	**1 mark** for correct XOR and AND gates, **with** correct inputs **1 mark** for correct NOT and NOR gates **with** correct inputs 	**2**
6(b)	**1 mark** for first 4 rows **1 mark** for last 4 rows	**2**

P	Q	R	Working space	Z
0	0	0		0
0	0	1		1
0	1	0		1
0	1	1		1
1	0	0		1
1	0	1		0
1	1	0		1
1	1	1		1

Answer 14

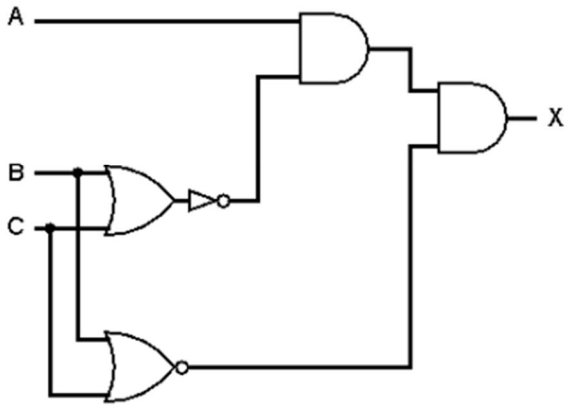
<table>
<tr><td>1(a)</td><td>NOT B</td><td>1</td></tr>
<tr><td>1(b)</td><td>1 mark for first 4 rows correct; 1 mark for second 4 rows correct

<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>1</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>1</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>0</td></tr>
<tr><td>1</td><td>1</td><td>1</td><td>1</td></tr>
</table></td><td>2</td></tr>
</table>

Answer 15

<table>
<tr><td>4(a)</td><td>1 mark for each set of 4 rows (shaded)

<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>1</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></td><td>2</td></tr>
</table>

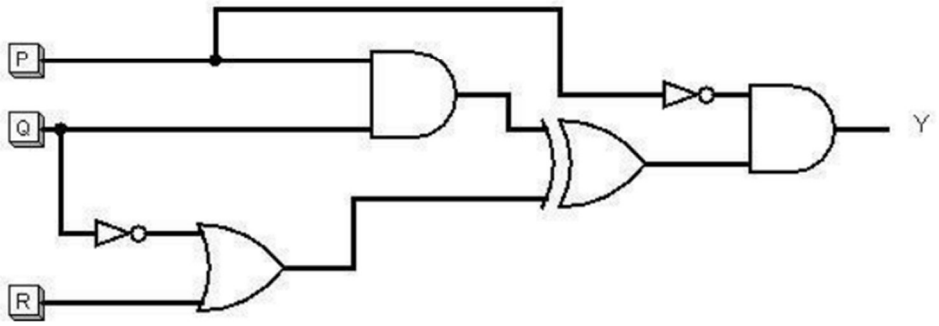
4(b)	**1 mark** for both AND gates **1 mark** for NOT gate <u>and</u> OR gate <u>and</u> NOR gate  	**2**

Answer 16

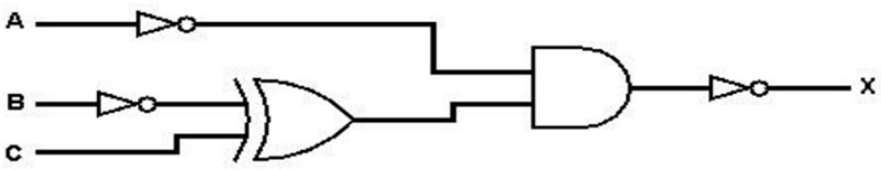
4(a)	**1 mark** for each bullet point • A NAND B • NOT(B XOR C) • Final NAND X = A NAND B NAND (NOT(B XOR C))	**3**
4(b)	**1 mark** for each set of rows (shaded)	**2**

A	B	C	X
0	0	0	**0**
0	0	1	**0**
0	1	0	**1**
0	1	1	**0**
1	0	0	**1**
1	0	1	**1**
1	1	0	**1**
1	1	1	**1**

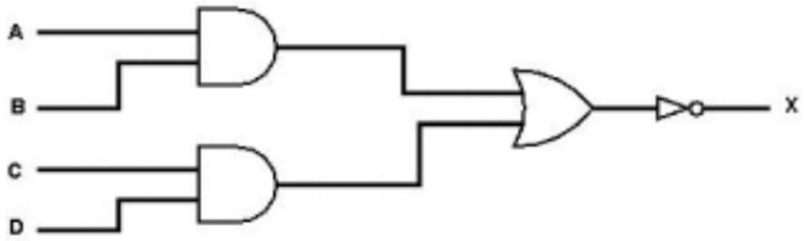
Answer 17

4(a)	**1 mark** for each set of highlighted rows **P** **Q** **R** **Y** 0 0 0 1 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**
4(b)	**1 mark** for **P** AND **Q** and NOT **Q** OR **R** **1 mark** for NOT gate and AND gate and XOR gate 	**2**

Answer 18

1(a)	**1 mark** for: (A XOR B) NOR C	**1**
1(b)	**1 mark** for NOT B XOR C **1 mark** for NOT A and final AND plus NOT 	**2**

Answer 19

1(a)	**1 mark** for each correct answer: *NAND* • The output is 0 when both inputs are 1, otherwise the output is 1 *NOR* • The output is 1 when both inputs are 0, otherwise the output is 0 *XOR* • The output is 1 when one of the inputs is 1 and the other input is 0, otherwise the output is 0 *OR* • The output is 0 when both inputs are 0, otherwise the output is 1	**4**
1(b)	**1 mark** for both AND gates with correct inputs **1 mark** for correct OR and NOT gates with correct inputs and no superfluous gates: 	**2**

Answer 20

6	**1 mark** for each correct line:	**3**

Truth table

A	B	C	X
0	0	0	0
0	0	1	1
0	1	0	0
0	1	1	0
1	0	0	1
1	0	1	1
1	1	0	0
1	1	1	0

A	B	C	X
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	0
1	1	1	1

A	B	C	X
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	0
1	1	1	1

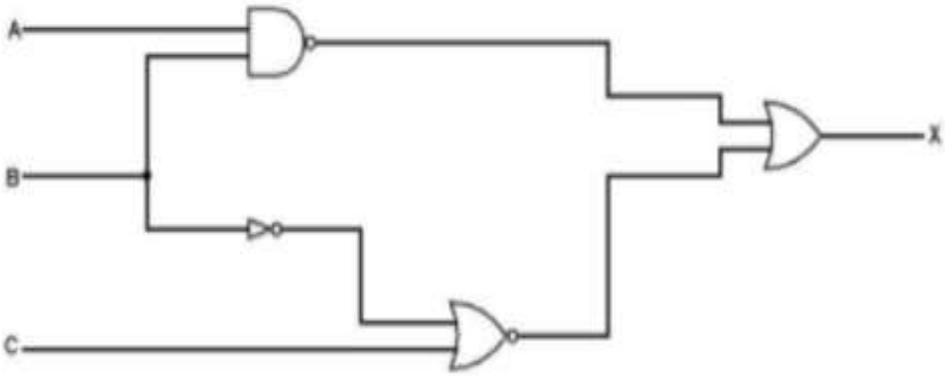
Logic expression

- NOT (A XOR B) AND C
- (A OR C) AND NOT B
- A NAND B NAND C
- (A NAND B) OR C
- NOT (A AND B AND C)

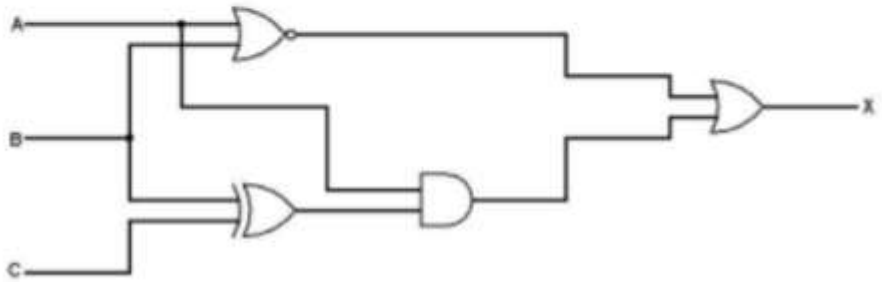
Answer 21

<table>
<tr><th>Question</th><th>Answer</th><th>Marks</th></tr>
<tr><td>5(a)</td><td>1 mark for each pair of correct answers (shaded)
<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>1</td></tr><tr><td>0</td><td>1</td><td>0</td><td></td><td>1</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>0</td></tr></table></td><td>4</td></tr>
<tr><td>5(b)</td><td>1 mark for name, 1 mark for symbol, 1 mark for truth table
• NAND
 
<table><tr><th colspan="2">Input</th><th rowspan="2">Output</th></tr><tr><th>A</th><th>B</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>• NOR
 
<table><tr><th colspan="2">Input</th><th rowspan="2">Output</th></tr><tr><th>A</th><th>B</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>3</td></tr>
</table>

Answer 22

Question	Answer	Marks
3	**1 mark** for each correct gate X = NOT (A AND B) OR NOT (NOT B OR C)  	**4**
4(a)(i)	**1 mark** only e.g. • Read about the languages she will be using • Visits the office prior to starting • Speaks to her manager about concerns	**1**

Answer 23

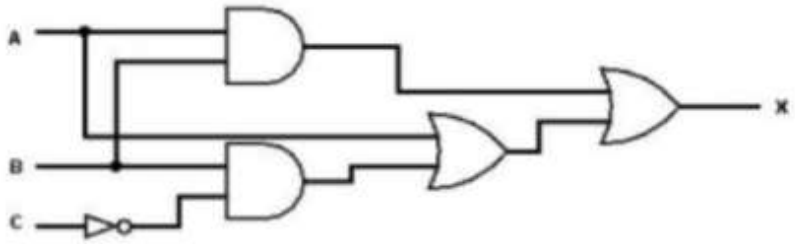
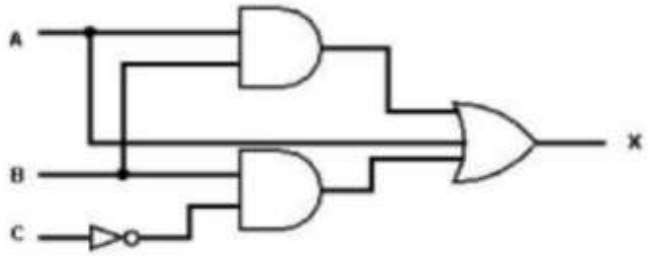
Question	Answer	Marks
3(a)	**1 mark** per correct gate • A NOR B • B XOR C • A AND (B XOR C) • Final OR 	4

Question	Answer	Marks
3(b)	**1 mark** for each correct pair of answers (4 shaded sections)	4

A	B	C	Working Space	X
0	0	0		1
0	0	1		1
0	1	0		0
0	1	1		0
1	0	0		0
1	0	1		1
1	1	0		1
1	1	1		0

3(c)	**1 mark** for name, **1 mark** for symbol matching the name NAND  NOR 	2

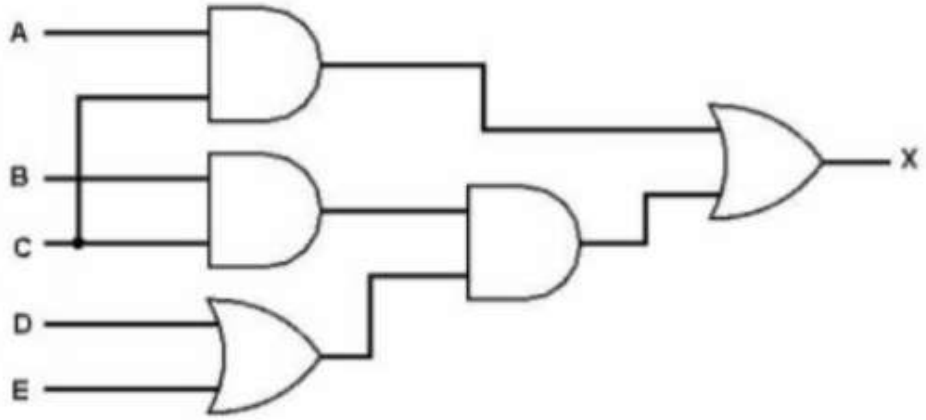
Answer 24

Question	Answer	Marks
6(a)	**1 mark** per gate The OR gates may be re-sequenced  Alternatively: 3-input OR gate **1 mark** for first three gates, and **2 marks** for 3-input OR gate 	5

Question	Answer	Marks
6(b)	**1 mark** for each pair of rows (shaded)	4

A	B	C	Working Space	X
0	0	0		0
0	0	1		0
0	1	0		1
0	1	1		0
1	0	0		1
1	0	1		1
1	1	0		1
1	1	1		1

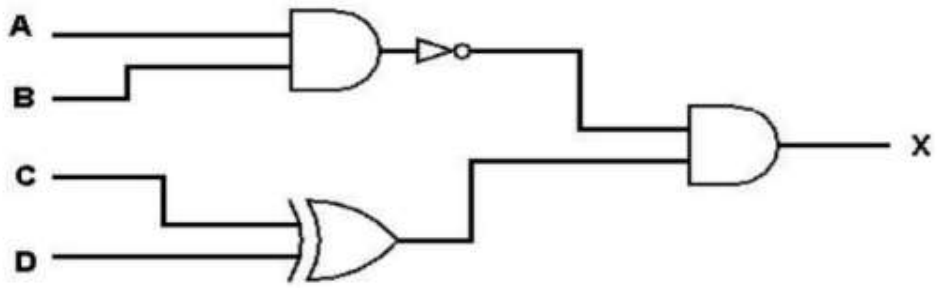
Answer 25

Question	Answer	Marks
3(a)	**1 mark** for each gate • A **AND** C • B **AND** C • D **OR** E • (B AND C) **AND** (D OR E) • Final **OR** 	5

Question	Answer	Marks
3(b)	**1 mark** for each pair of correct rows	4

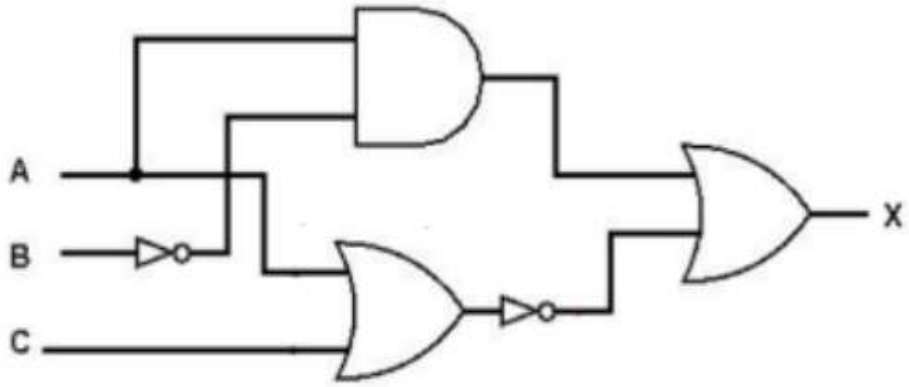
A	B	C	Working space	X
0	0	0		0
0	0	1		1
0	1	0		1
0	1	1		0
1	0	0		0
1	0	1		1
1	1	0		0
1	1	1		1

Answer 26

Question	Answer	Marks
2(a)	**1 mark** per gate 	4
2(b)	**1 mark** for each pair of answers	4

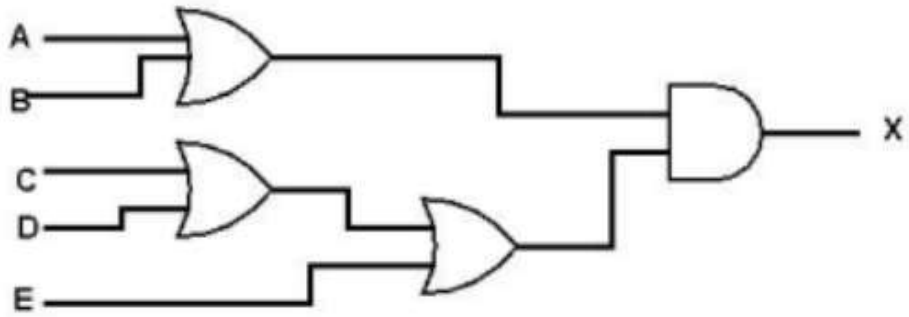
A	B	C	Working space	X
0	0	0		1
0	0	1		1
0	1	0		1
0	1	1		1
1	0	0		1
1	0	1		1
1	1	0		1
1	1	1		0

Answer 27

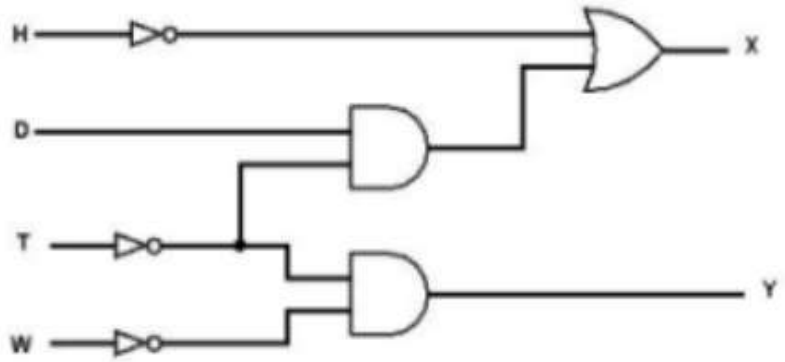
Question	Answer	Marks
5(a)	**1 mark** for each correct gate • A **OR** C • **NOT**(A OR C) • **NOT** B • A **AND** NOT B • Final **OR** 	5
5(b)	**1 mark** for each pair of rows	4

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

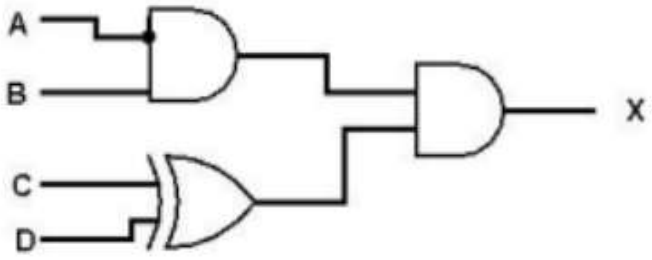
Answer 28

<table>
<tr><th>Question</th><th>Answer</th><th>Marks</th></tr>
<tr><td>4(a)</td><td>1 mark per bullet:
• A OR B
• C OR D OR E
• Final AND
 
</td><td>3</td></tr>
<tr><td>4(b)</td><td>1 mark for each correct pair of rows
<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>1</td></tr>
<tr><td>0</td><td>1</td><td>0</td><td></td><td>1</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>1</td></tr>
<tr><td>1</td><td>1</td><td>1</td><td></td><td>1</td></tr>
</table></td><td>4</td></tr>
</table>

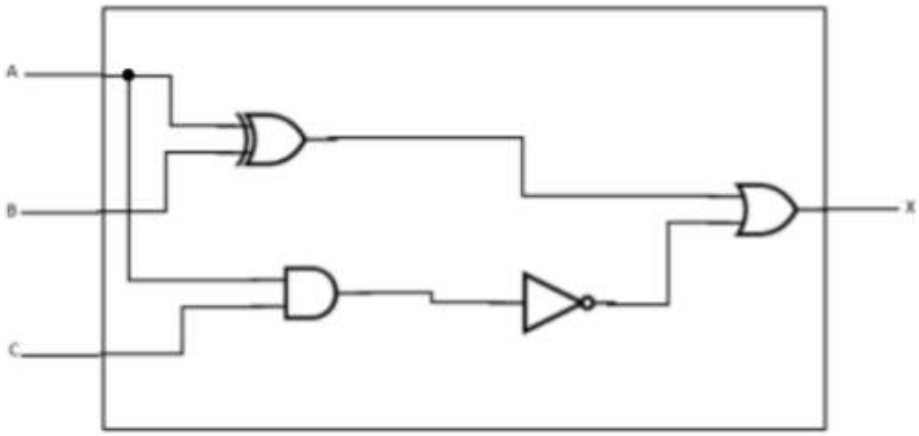
Answer 29

<table>
<tr><th>Question</th><th>Answer</th><th>Marks</th></tr>
<tr><td>2(a)</td><td>1 mark for each gate with the correct inputs.
Final two gates must also have the correct output.
 
</td><td>6</td></tr>
<tr><td>2(b)</td><td>One mark for each pair of rows.
<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>1</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>1</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>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></td><td>4</td></tr>
</table>

Answer 30

<table>
<tr><th>Question</th><th>Answer</th><th>Marks</th></tr>
<tr><td>5(a)</td><td>1 mark per correct gate with correct inputs
 
</td><td>3</td></tr>
<tr><td>5(b)</td><td>1 mark for each correct pair of lines
<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>1</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>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></td><td>4</td></tr>
</table>

Answer 31

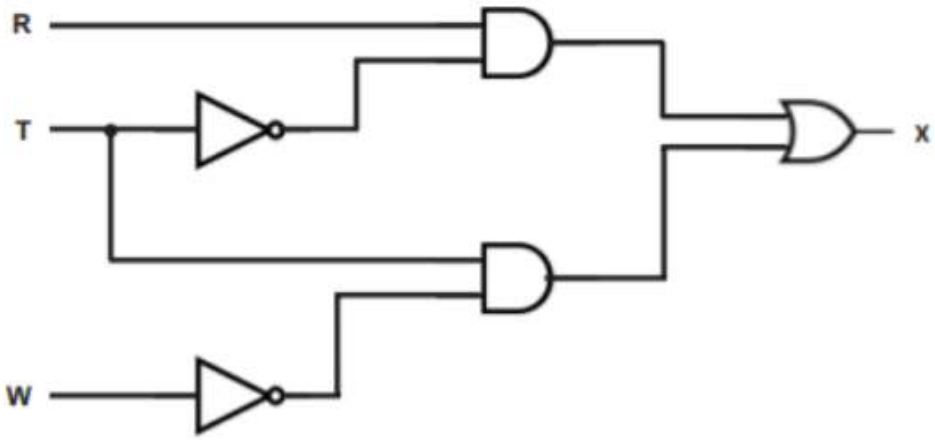
Question	Answer	Marks
8(a)	**1 mark** for each logic gate with the correct inputs 	4

Question	Answer	Marks
8(b)	**One mark** for each correct pair of lines	4

A	B	C	Working Space	X
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		0

Answer 32

5 (a) (i) **One mark** for each correct gate.



[5]

(ii) $\underline{(R.\bar{T})} + \underline{(T.\bar{W})}$ // <u>(R AND NOT T)</u> <u>OR (T AND NOT W)</u> [2]

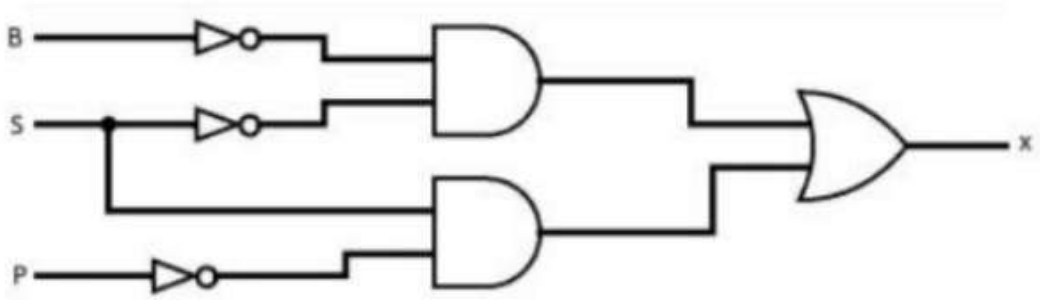
(iii) **One mark** for each pair of lines as shaded.

INPUT			Working space	OUTPUT X
R	T	W		
0	0	0		0
0	0	1		0
0	1	0		1
0	1	1		0
1	0	0		1
1	0	1		1
1	1	0		1
1	1	1		0

[4]

Answer 33

1 (a) **ONE** mark for each correct gate.



[6]

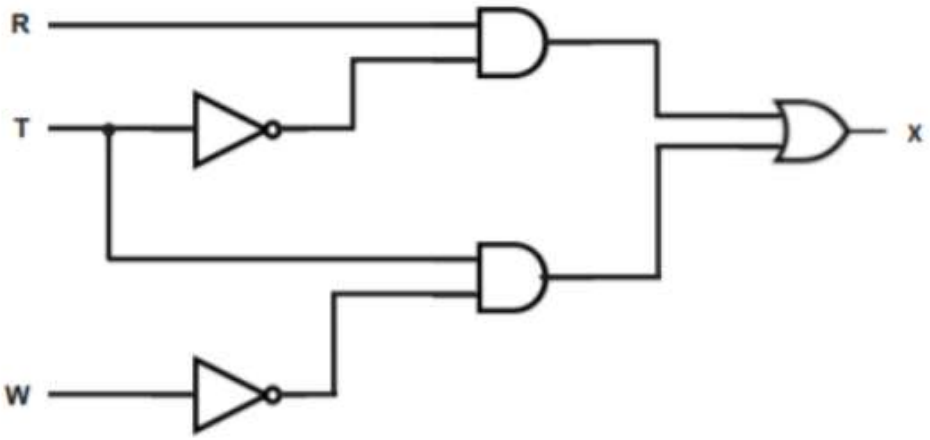
(b) **ONE** mark for each pair of rows.

B	S	P	Working space	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]

Answer 34

5 (a) (i) **One mark** for each correct gate.



[5]

(ii) $\underline{(R.\bar{T})}+\underline{(T.\bar{W})}$ // <u>(R AND NOT T)</u> <u>OR (T AND NOT W)</u> [2]

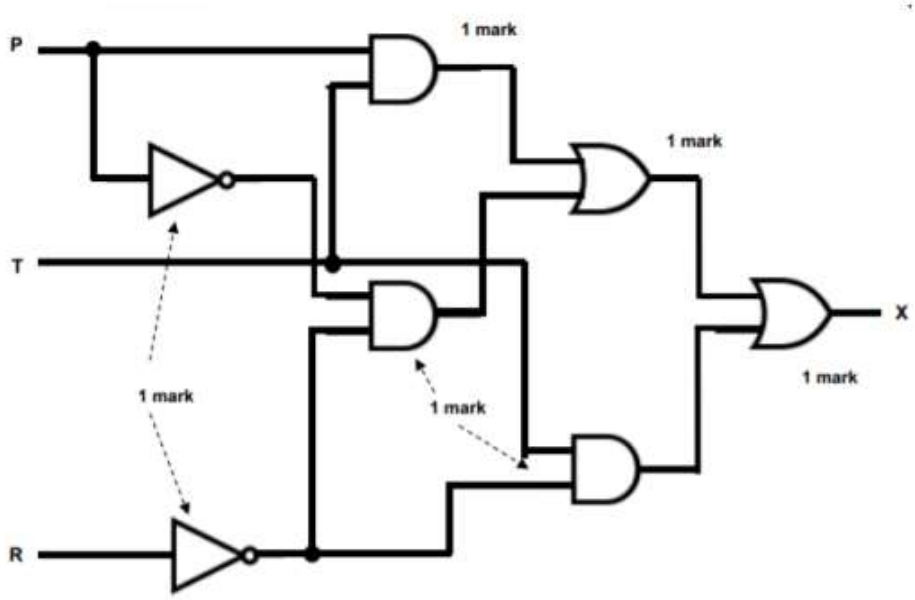
(iii) **One mark** for each pair of lines as shaded.

INPUT			Working space	OUTPUT X
R	T	W		
0	0	0		0
0	0	1		0
0	1	0		1
0	1	1		0
1	0	0		1
1	0	1		1
1	1	0		1
1	1	1		0

[4]

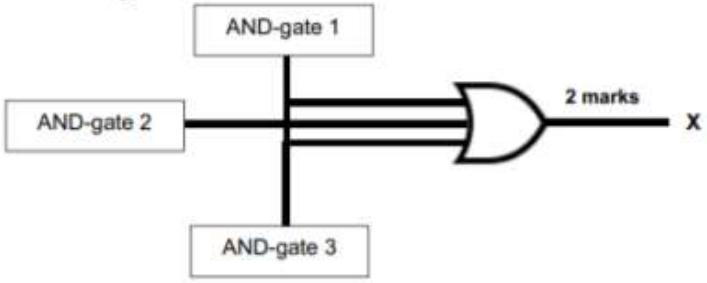
Answer 35

7 (a) since it is possible to simplify the original conditions, at least 3 possible answers exist for the logic circuit.

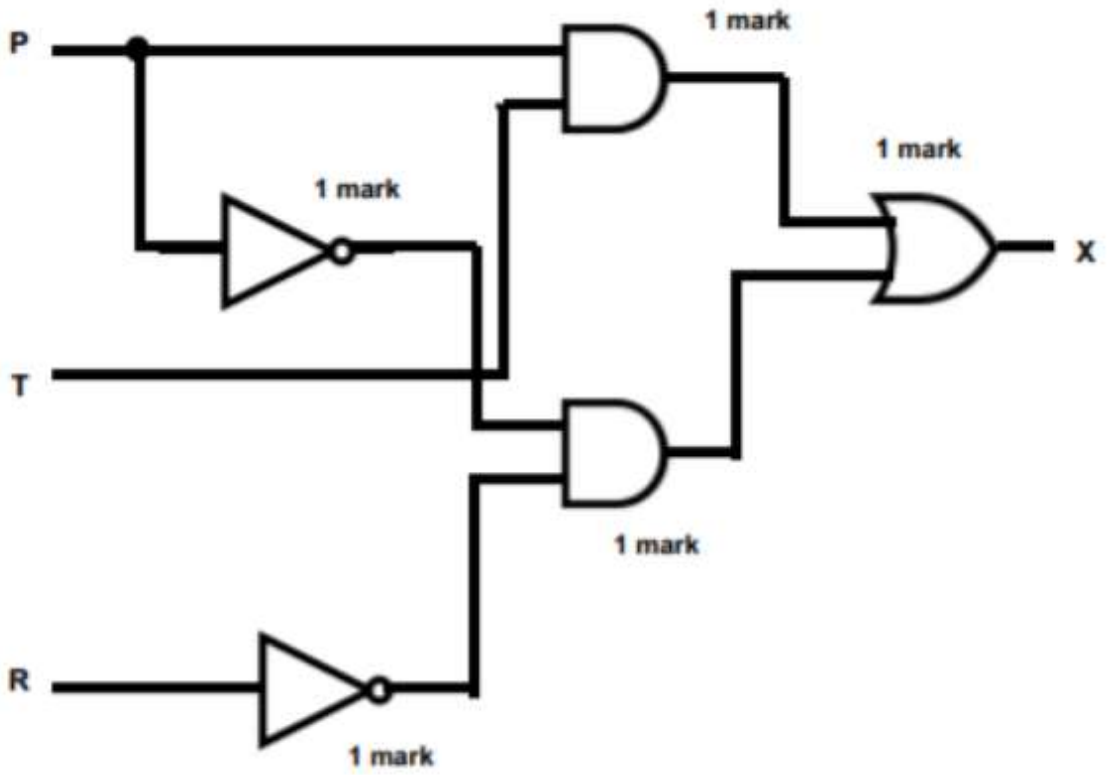


Note: input T has 2 cross overs that should not be connections

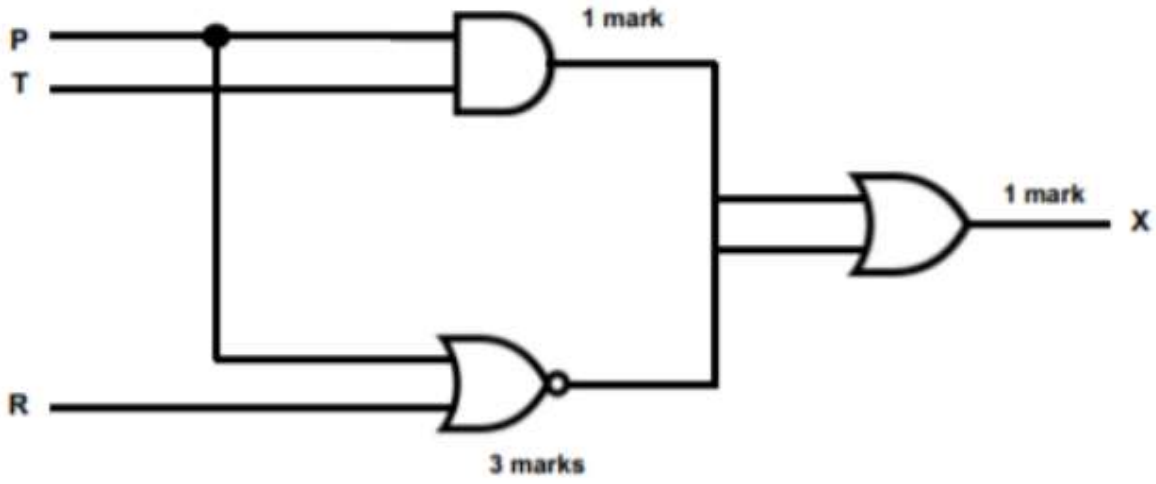
Note: it is possible to use a 3-input OR gate rather than the two 2-input OR gates on the top right:



Alternative solution 1:



Alternative solution 2:



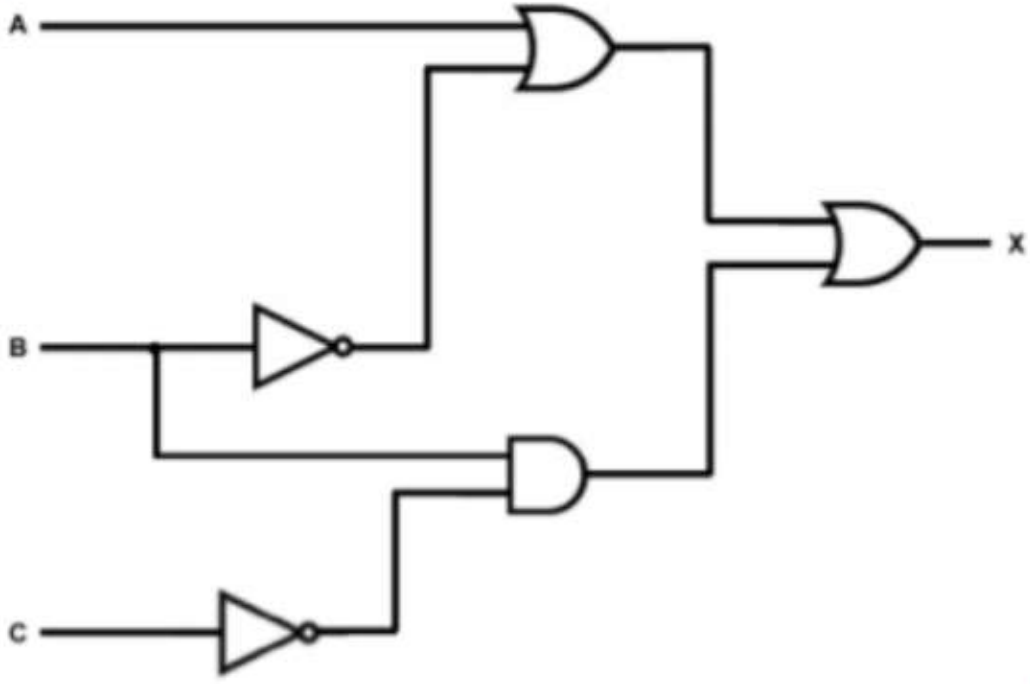
(b)

P	T	R	Workspace	X	
0	0	0		1	} 1 mark
0	0	1		0	
0	1	0		1	} 1 mark
0	1	1		0	
1	0	0		0	} 1 mark
1	0	1		0	
1	1	0		1	} 1 mark
1	1	1		1	

[4]

Answer 36

6 (a)



[5]

(b)

A	B	C	working	X	
0	0	0		1	} 1 mark
0	0	1		1	
0	1	0		1	} 1 mark
0	1	1		0	
1	0	0		1	} 1 mark
1	0	1		1	
1	1	0		1	} 1 mark
1	1	1		1	

[4]

(c) ((A is NOT 1 AND B is 1) OR (B is NOT 1 OR C is 1)) AND C is NOT 1

< – – – – – 1 mark – – – – – > < – – – – – 1 mark – – – – – > < – – – – –1 mark – – – – – >

NOTE: all brackets may not be shown – but check answer still correct

Alternatives include:

((NOT A AND B) OR (NOT B OR C)) AND NOT C

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

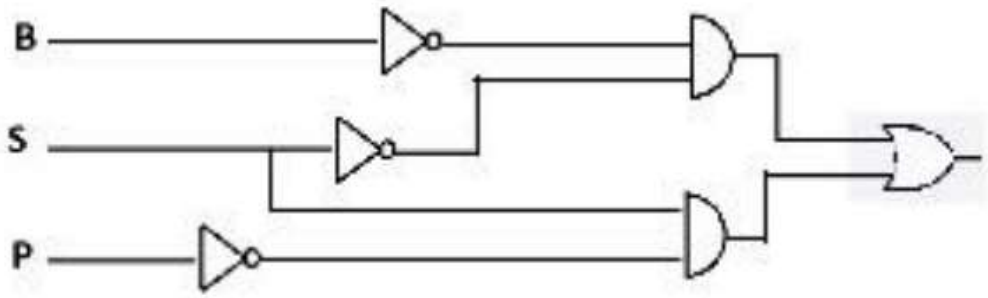
NOTE: expressions may be reversed but still OK

(e.g. NOT C AND ((NOT A AND B) OR (NOT B OR C))

NOT C AND ((NOT B OR C) OR (NOT A AND B)) and so on) [3]

Answer 37

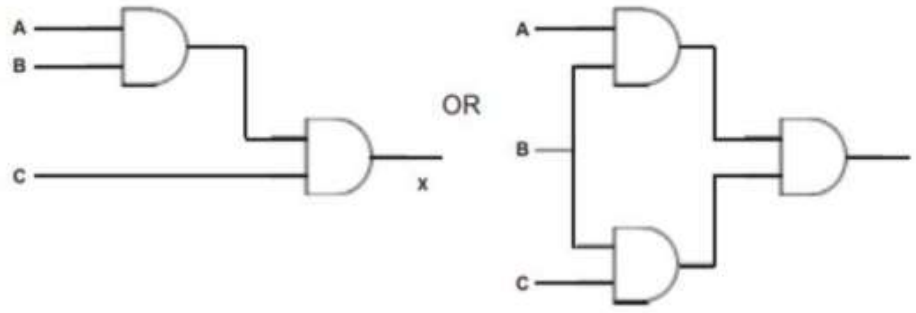
B	S	P	X
0	0	0	1
0	0	1	1
0	1	0	1
0	1	1	0
1	0	0	0
1	0	1	0
1	1	0	0
1	1	1	0



Answer 38

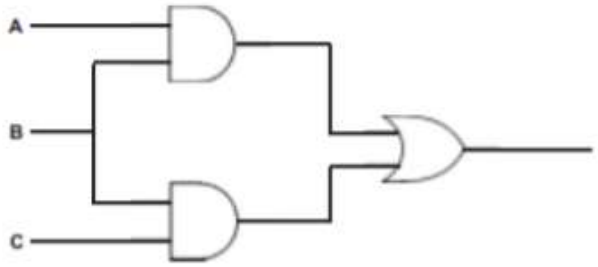
8 (a) 2 marks per part
IF candidate uses 2 gates mark from 2 gate diagram if draws 3 gates mark from 3 gate diagram for all 3 parts

(i) (allow correct alternatives)



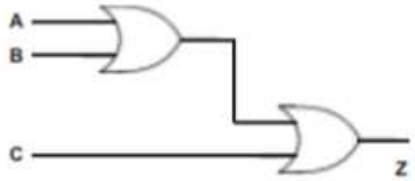
[2]

(ii)

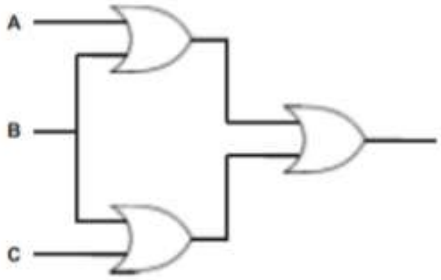


[2]

(iii) (allow correct alternatives)



OR



[2]

(b)

A	B	C	X	Y	Z
0	0	0	**0**	**0**	**0**
0	0	1	**0**	**0**	**1**
0	1	0	**0**	**0**	**1**
0	1	1	**0**	**1**	**1**
1	0	0	**0**	**0**	**1**
1	0	1	**0**	**0**	**1**
1	1	0	**0**	**1**	**1**
1	1	1	**1**	**1**	**1**

2 marks 2 marks 2 marks

(–1 mark for each error in each column) [6]

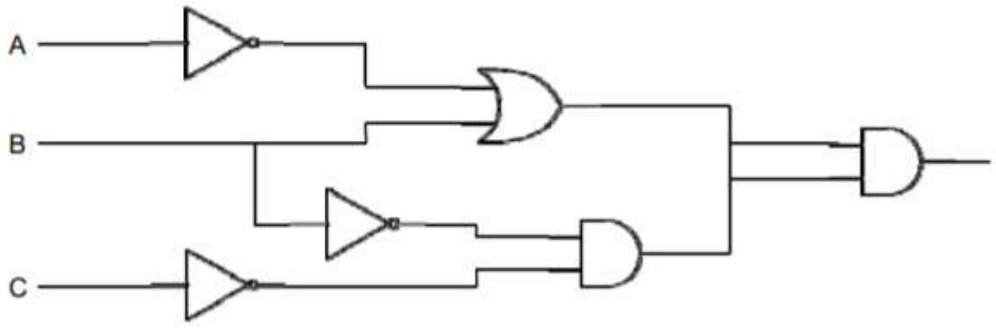
Answer 39

8 (a)

A	B	C	X	
0	0	0	**1**	1 mark
0	0	1	**1**	
0	1	0	**0**	1 mark
0	1	1	**0**	
1	0	0	**0**	1 mark
1	0	1	**1**	
1	1	0	**0**	1 mark
1	1	1	**0**	

[4]

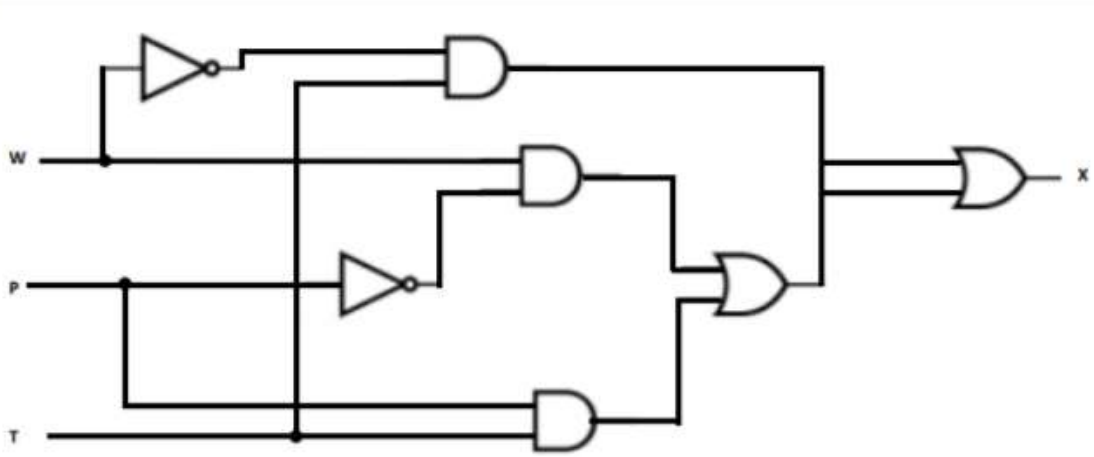
(b) 1 mark per correct logic gate in correct position



[6]

Answer 40

6 (a)



(corresponds to: [W = 1 AND P = NOT 1] OR [T = 1 AND P = 1] OR [W = NOT 1 AND T = 1])

1 mark for each correct logic gate in correct position – **[7]**

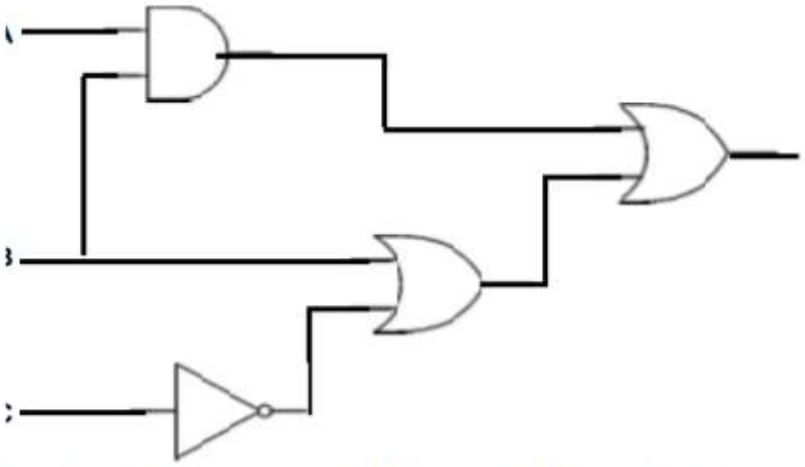
(b)

input W	input P	input T	output X	
0	0	0	**0**	1 mark
0	0	1	**1**	
0	1	0	**0**	1 mark
0	1	1	**1**	
1	0	0	**1**	1 mark
1	0	1	**1**	
1	1	0	**0**	1 mark
1	1	1	**1**	

[4]

Answer 41

9 **(a)** 1 mark for each correct logic gate (accept other logic gate nomenclature)



If a candidate has only one input to AND gate or an OR gate they lose the mark for that gate

[4]

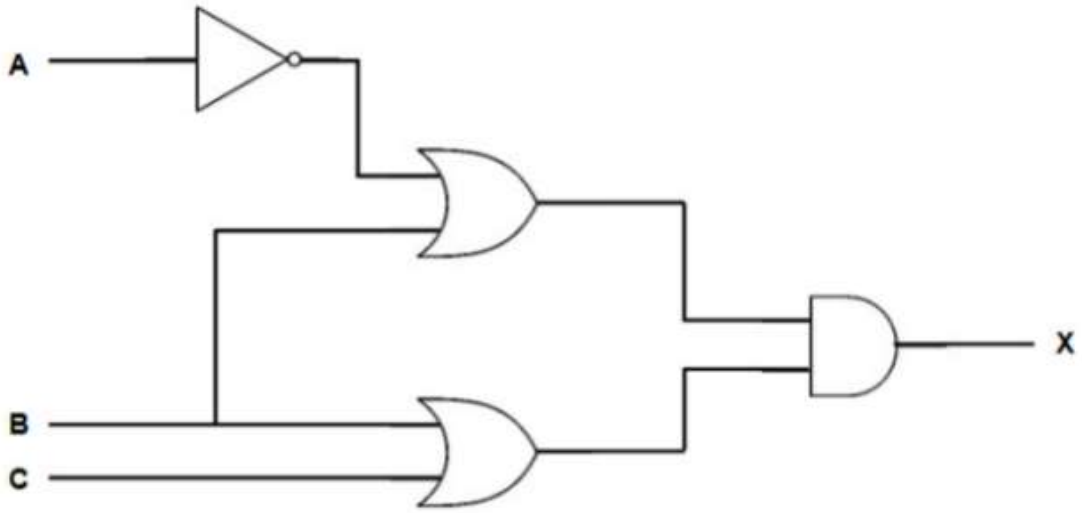
(b)

A	B	C	X
0	0	0	1
0	0	1	0
0	1	0	1
0	1	1	1
1	0	0	1
1	0	1	0
1	1	0	1
1	1	1	1

[4]

Answer 42

4 (a) 1 mark for each correct logic gate



[4]

(b)

A	B	C	X	
0	0	0	0	1 mark
0	0	1	1	
0	1	0	1	1 mark
0	1	1	1	
1	0	0	0	1 mark
1	0	1	0	
1	1	0	1	1 mark
1	1	1	1	

[4]

Answer 43

9 **(a)**

A	B	X
0	0	**1**
0	1	**0**
1	0	**0**
1	1	**0**

(1 mark for the 1,0 and 1 mark for 0, 0) [2]

(b)

A	B	C	D	Y
0	0	**0**	**1**	**0**
0	1	**1**	**0**	**0**
1	0	**1**	**1**	**1**
1	1	**1**	**0**	**0**

(1 mark for each row). [4]