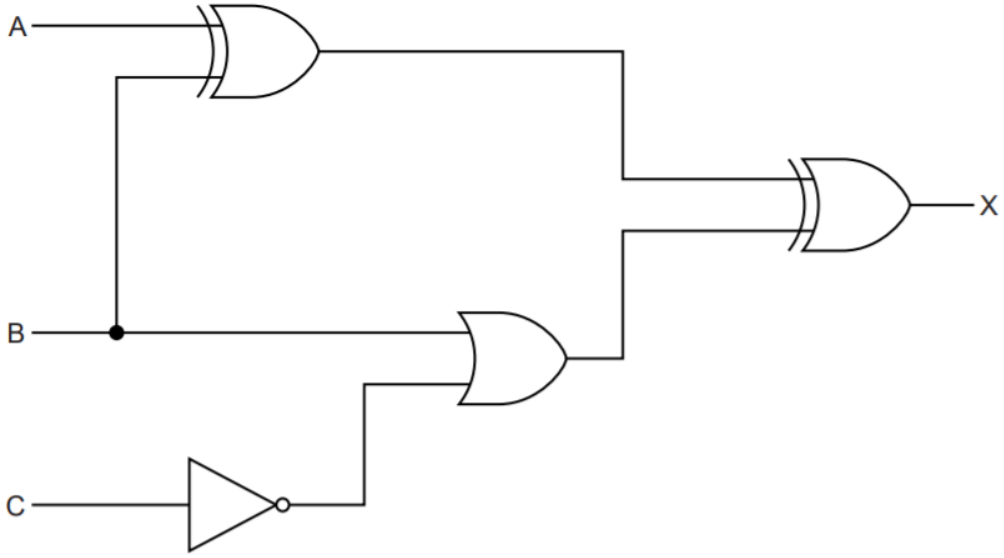
Computer Science

10. Boolean Logic

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

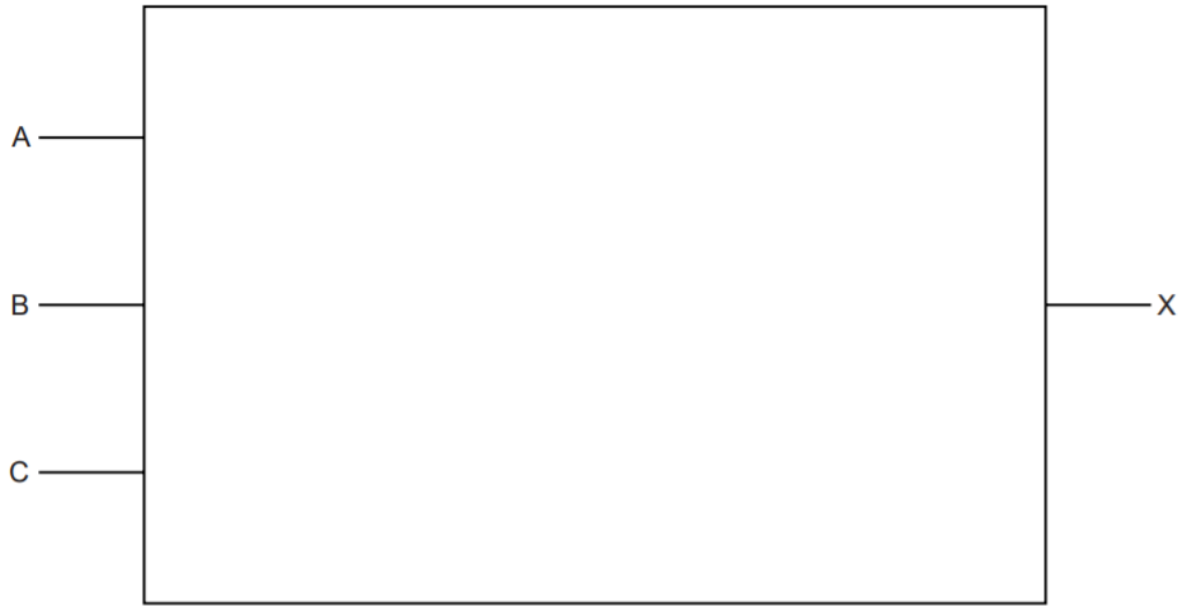


A	B	C	Workspace	X
0	0	0		
0	0	1		
0	1	0		
0	1	1		
1	0	0		
1	0	1		
1	1	0		
1	1	1		

[4]

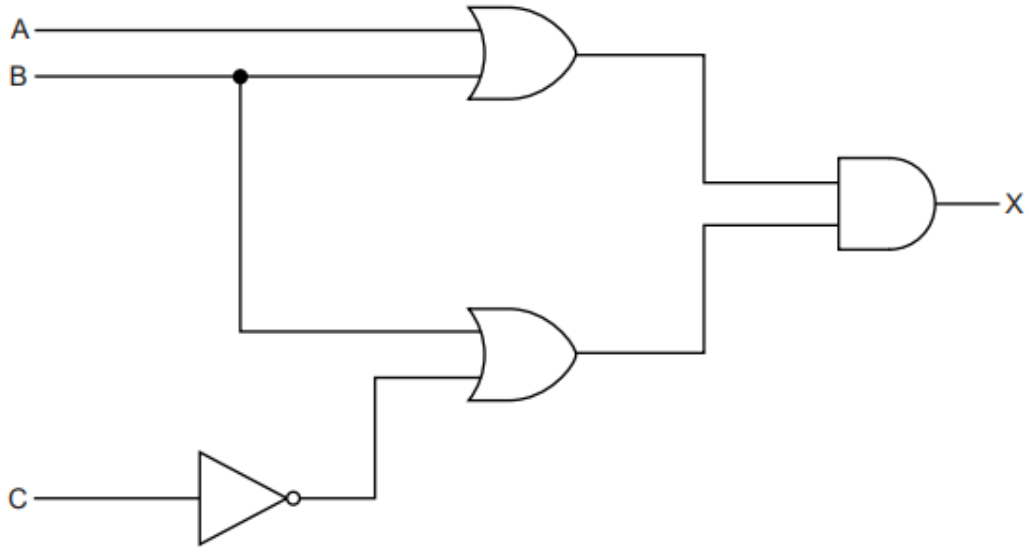
(b) Draw a logic circuit which corresponds to the following logic statement:

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



[3]

(c) Write a logic statement which corresponds to the following logic circuit:



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[3]

2 A gas fire has a safety circuit made up of logic gates. It generates an alarm (X = 1) in response to certain conditions.

Input	Description	Binary value	Conditions
G	gas pressure	1	gas pressure is correct
		0	gas pressure is too high
C	carbon monoxide level	1	carbon monoxide level is correct
		0	carbon monoxide level is too high
L	gas leak detection	1	no gas leak is detected
		0	gas leak is detected

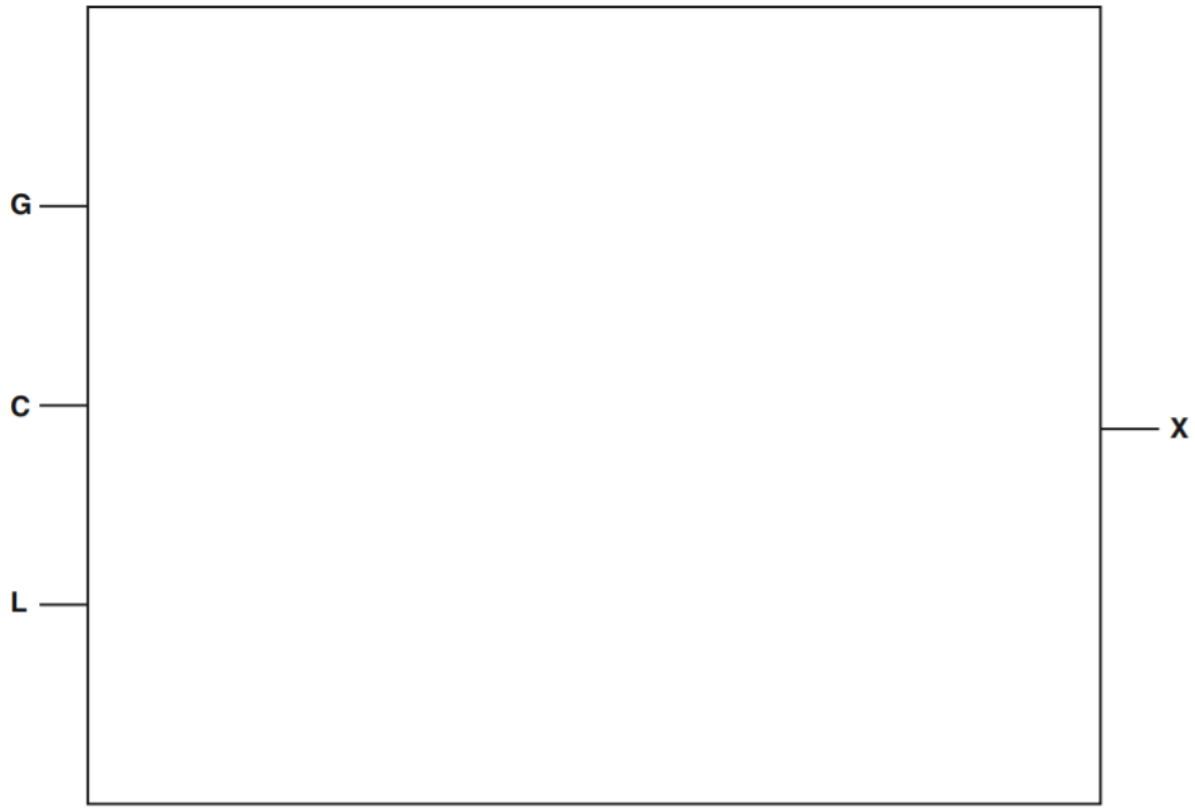
The output X = 1 is generated under the following conditions:

gas pressure is correct **AND** carbon monoxide level is too high

OR

carbon monoxide level is correct **AND** gas leak is detected

(a) Draw a logic circuit for this safety system.



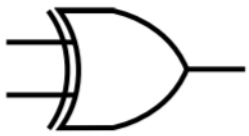
[5]

(b) Complete the truth table for the safety system.

G	C	L	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]

(c) Complete the truth table for the XOR gate:



A	B	C
0	0	
0	1	
1	0	
1	1	

[1]

3 A computer-controlled machine produces plastic sheets. The thickness of each sheet must be within a certain tolerance. The sheets are kept below 50 °C as they move over rollers at 10 metres per second.

Three parameters need to be monitored all the time.

Parameter	Description	Binary value	Conditions
D	sheet thickness	1	thickness of sheet in tolerance
		0	thickness of sheet out of tolerance
S	roller speed	1	roller speed = 10 metres/second
		0	roller speed <> 10 metres/second
T	temperature	1	temperature < 50 °C
		0	temperature >= 50 °C

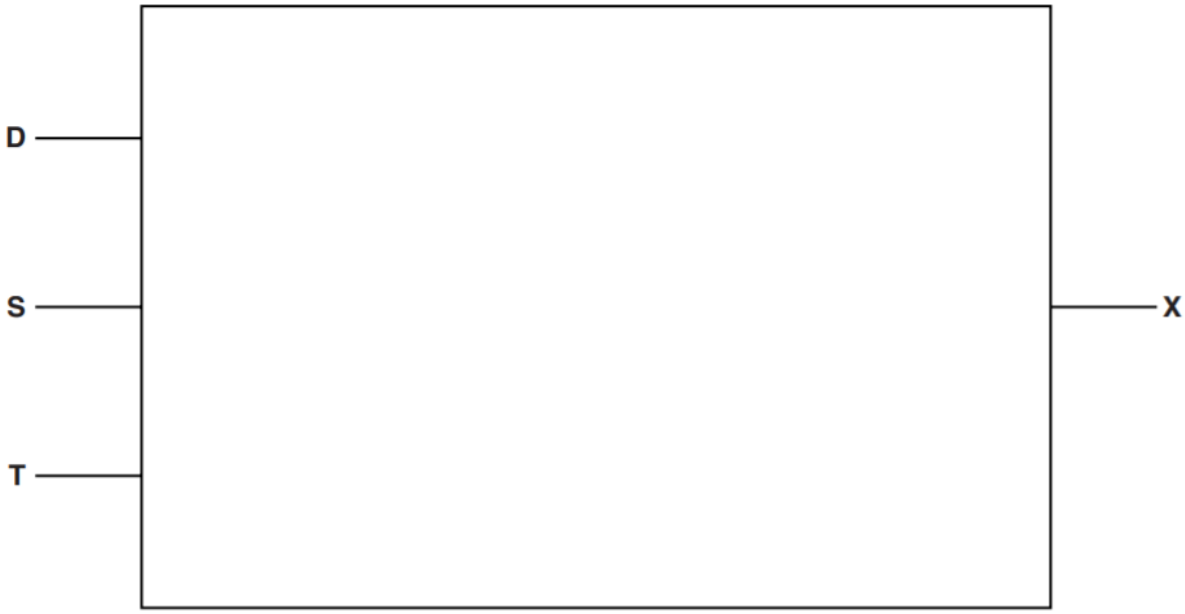
An alarm, **X**, will sound if:

thickness is in tolerance AND (roller speed <> 10 metres/second OR temperature >= 50 °C)

OR

roller speed = 10 metres/second AND temperature >= 50 °C

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



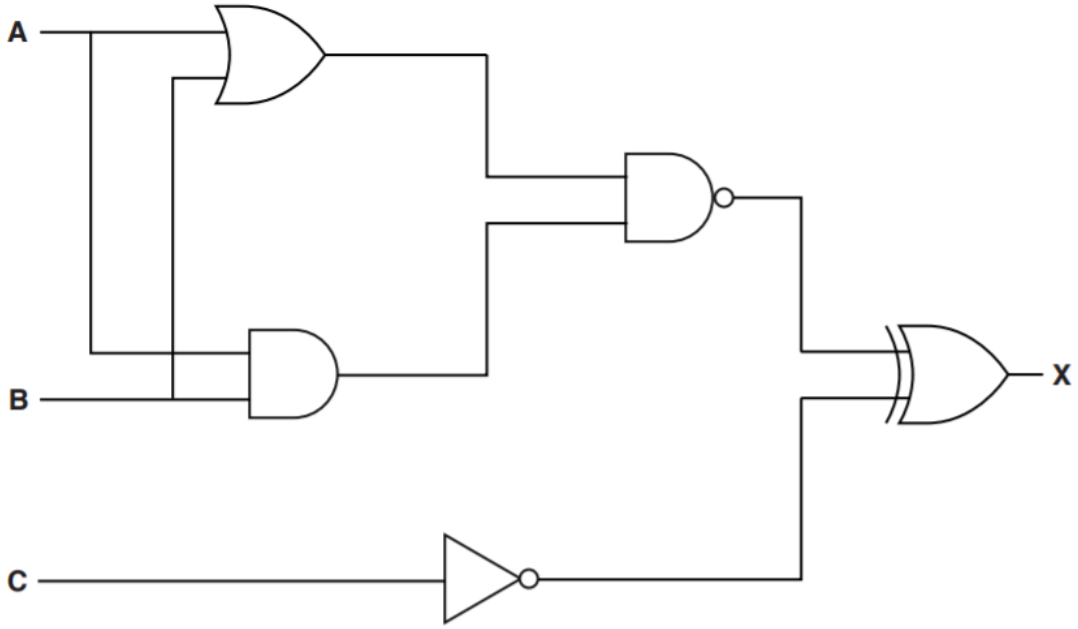
[6]

(b) Complete the truth table for the monitoring system.

D	S	T	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]

4 (a)



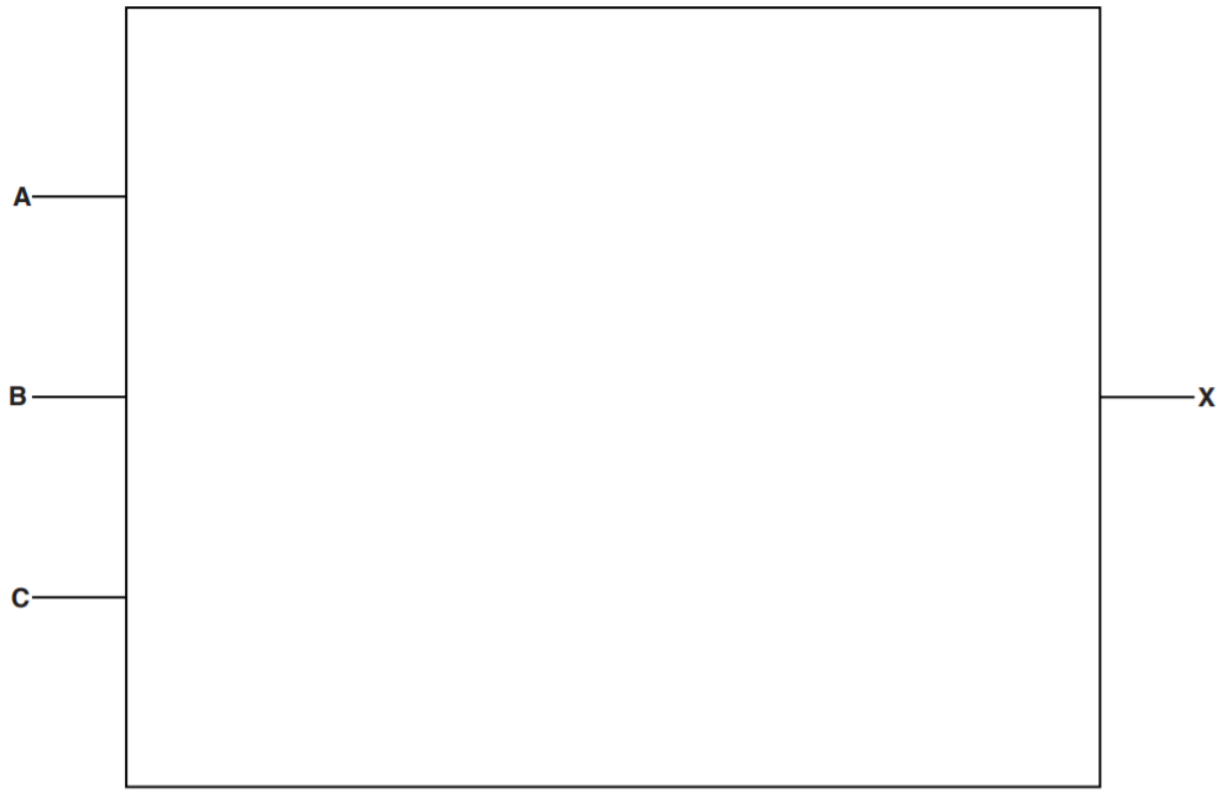
Complete the truth table for this logic circuit.

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		

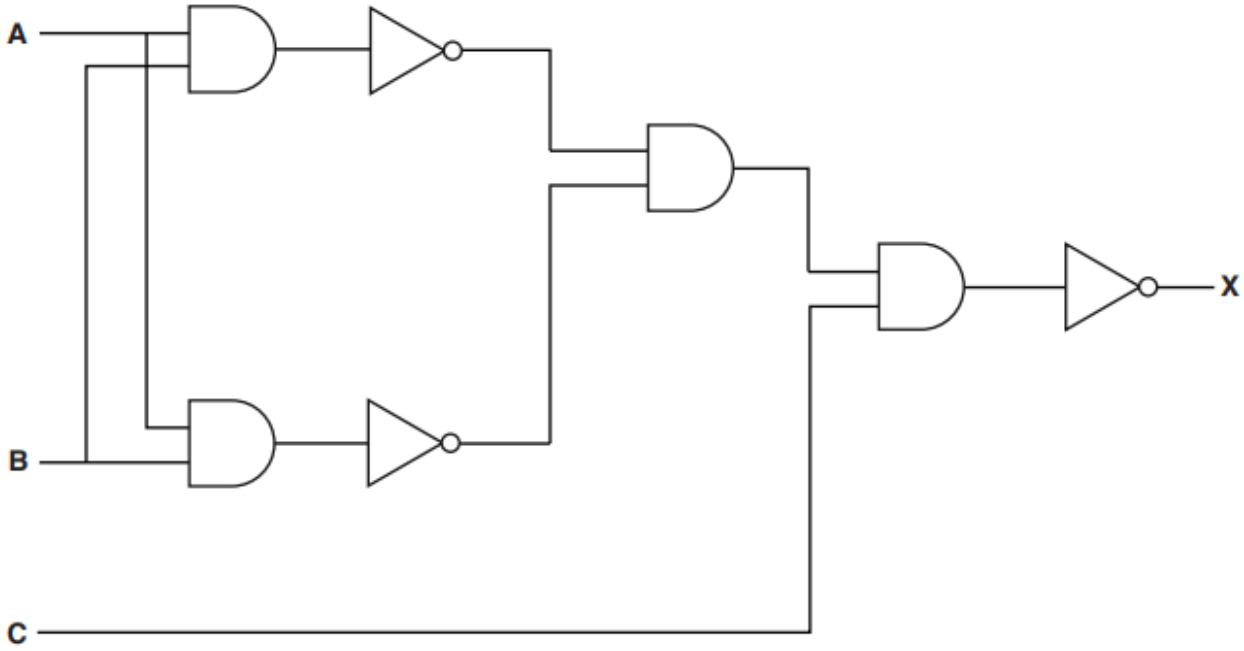
[4]

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

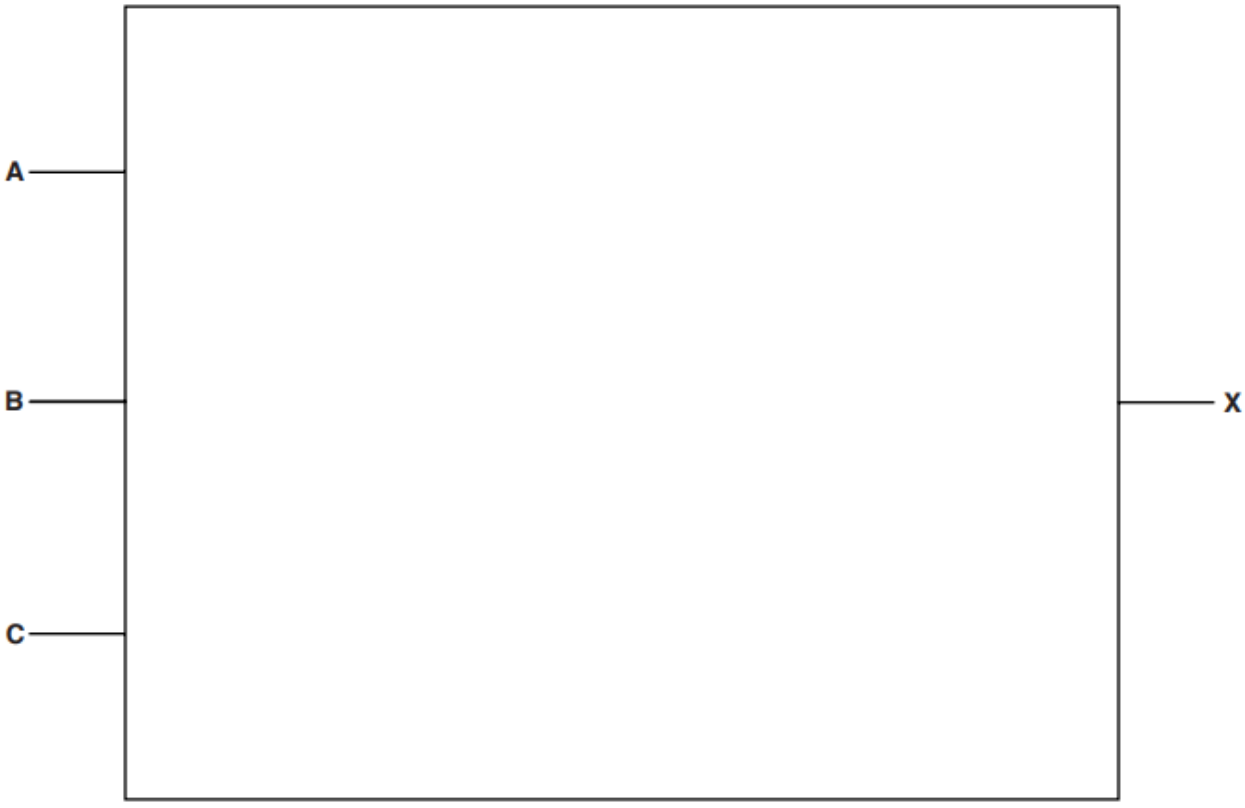
X = 1 if ((A is 1 OR B is 1) AND (A is 1 AND B is 1)) OR (C is NOT 1)



(c) Re-draw the following logic circuit using NAND gates only.



Logic circuit re-drawn:



[4]

5 A computer-controlled machine produces plastic sheets. The thickness of each sheet must within a certain tolerance. The sheets are kept below 50 °C as they move over rollers at 10 metr per second.

Three parameters need to be monitored all the time.

Parameter	Description	Binary value	Conditions
D	sheet thickness	1	thickness of sheet in tolerance
		0	thickness of sheet out of tolerance
S	roller speed	1	roller speed = 10 metres/second
		0	roller speed <> 10 metres/second
T	temperature	1	temperature < 50 °C
		0	temperature >= 50 °C

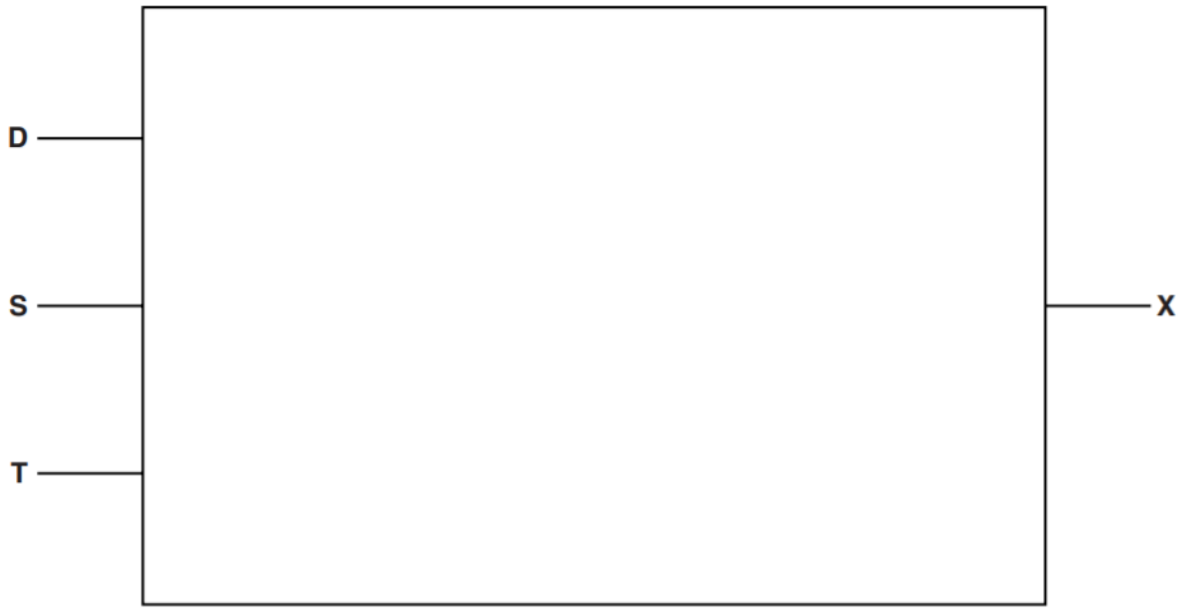
An alarm, **X**, will sound if:

thickness is in tolerance AND (roller speed <> 10 metres/second OR temperature >= 50 °C)

OR

roller speed = 10 metres/second AND temperature >= 50 °C

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



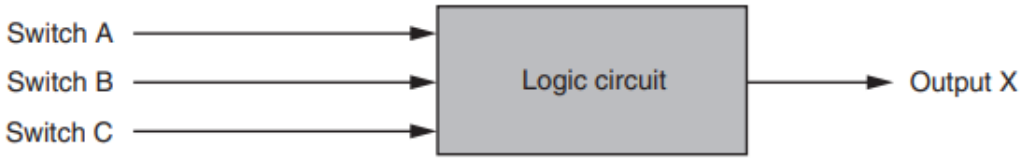
[6]

(b) Complete the truth table for the monitoring system.

D	S	T	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]

6 Three switches, A, B and C, each send values of 0 or 1 to a logic circuit. Value X is output from the logic circuit.



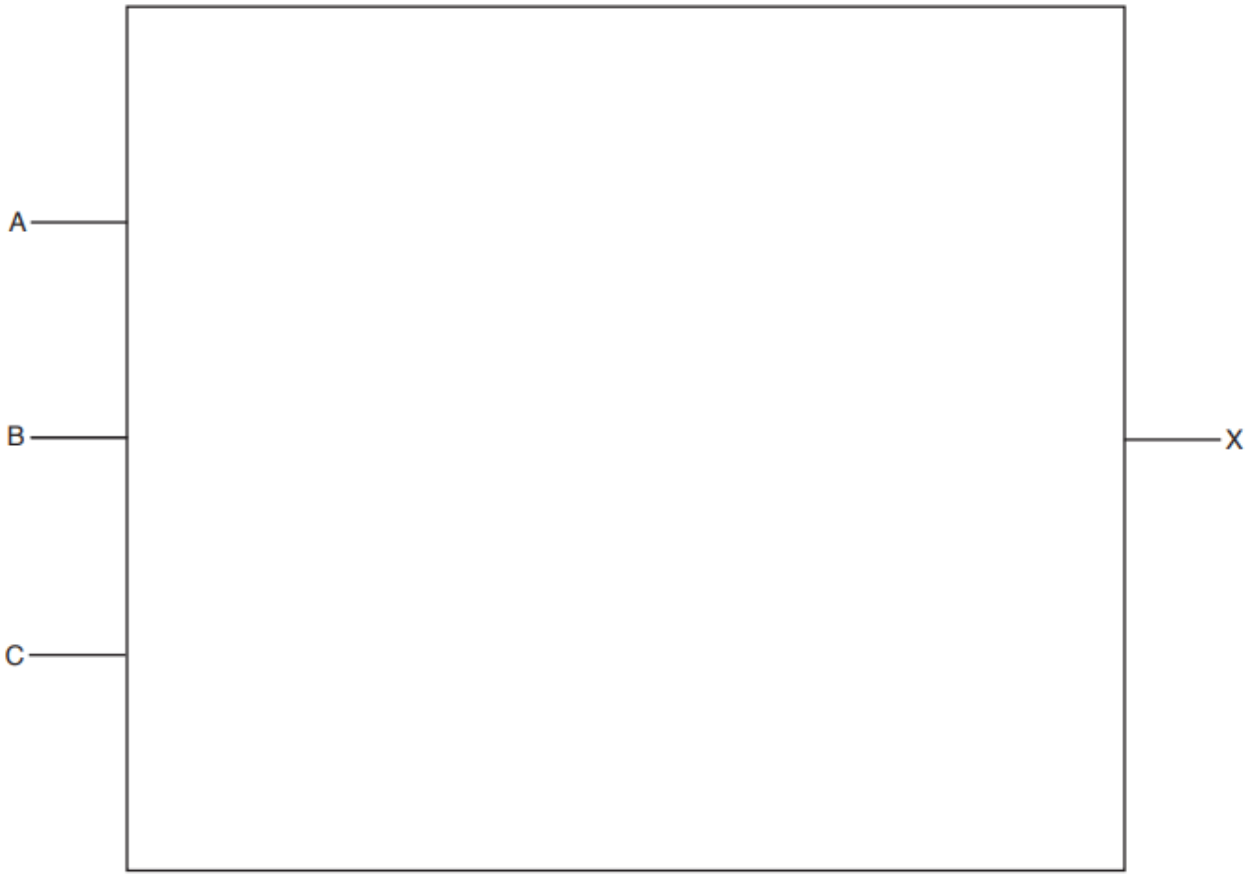
Output X has a value of 1 depending on the following conditions:

Switch A sends value 1 AND Switch B sends value 0

OR

Switch B sends value 1 AND Switch C sends value 0

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



[5]

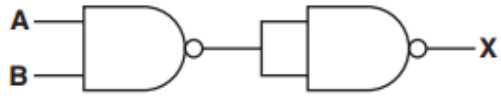
(b) Complete the truth table for the conditions given at the start of question 5.

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]

7 **(a)** Complete the truth tables and name the single logic gate that could replace each logic circuit:

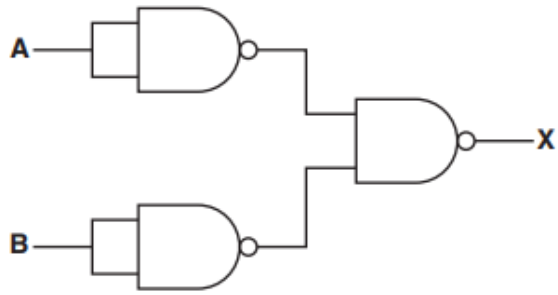
(i)



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

Single logic gate .....[3]

(ii)

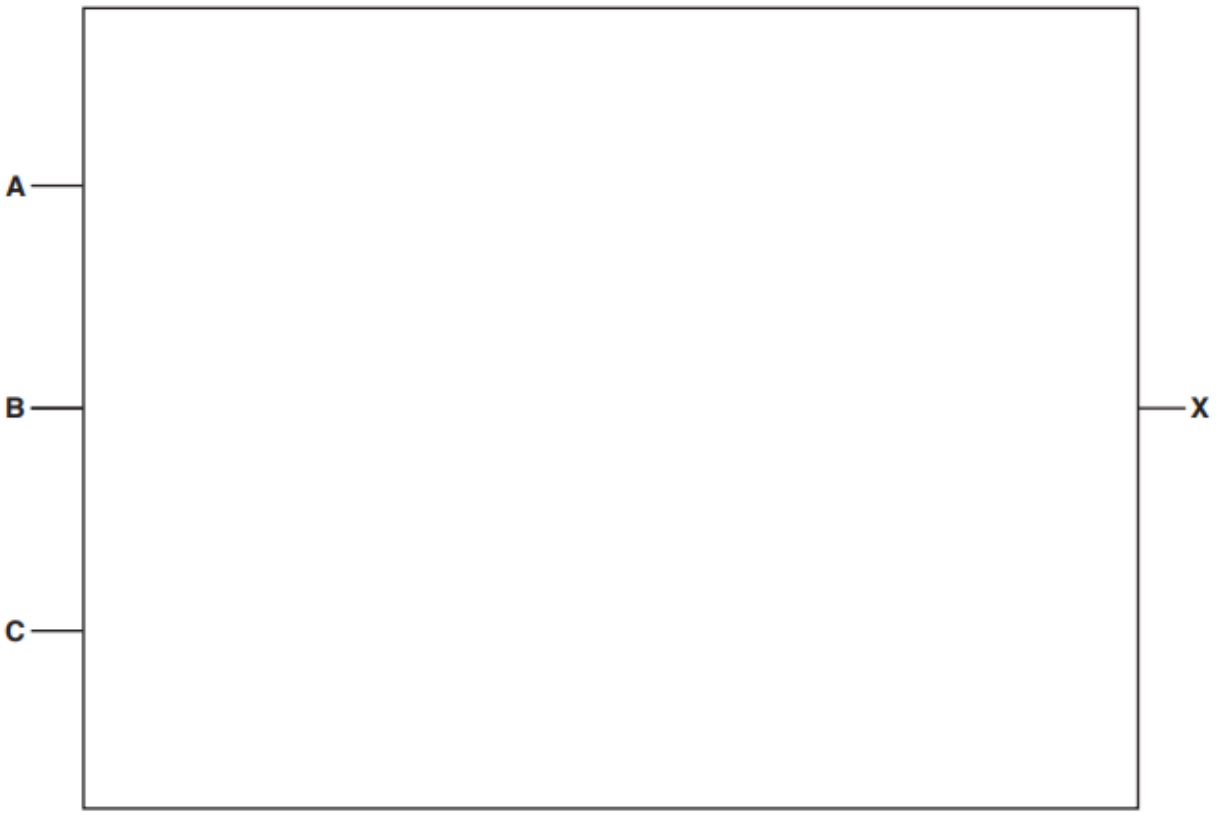


A	B	Working space	X
0	0		
0	1		
1	0		
1	1		

Single logic gate .....[3]

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

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



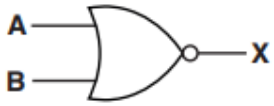
[4]

(ii) Complete the truth table for the logic statement in **part (b)(i)**.

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]

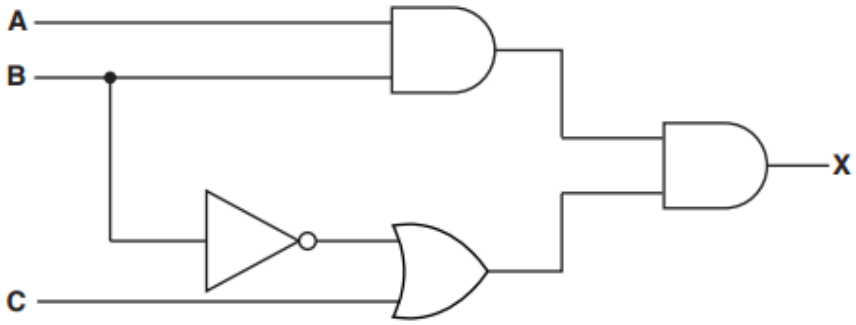
8 **(a)** Complete the truth table for the NOR gate.



A	B	Output (X)
0	0	
0	1	
1	0	
1	1	

[1]

(b) Write a logic statement that corresponds with the following logic circuit.



X = ... [3]

9 For this logic statement:

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

(a) Draw the logic circuit.

[4]

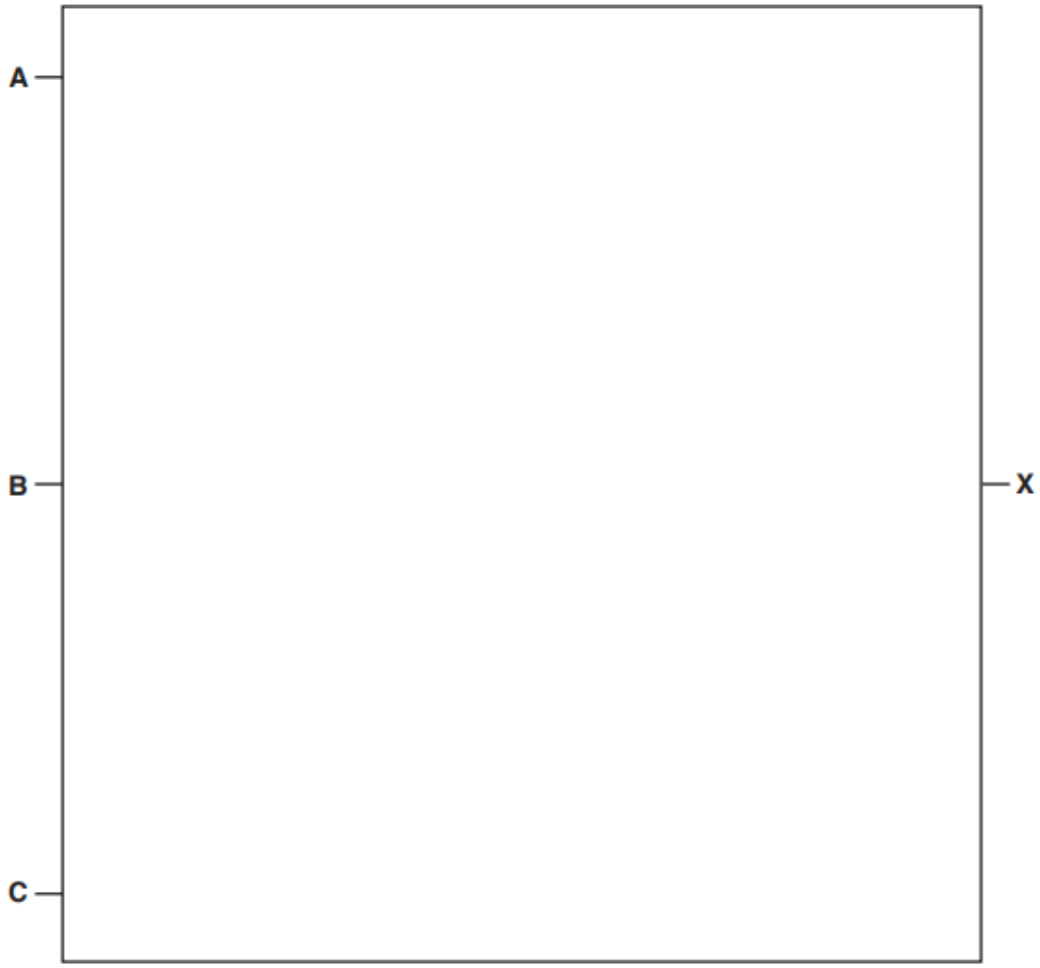
(b) Complete the truth table for the given logic statement.

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]

10 **(a)** Draw a logic circuit for the logic statement:

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



[4]

(b) Draw the symbol for an **XOR** gate and explain the function of this logic gate.

Explanation .....

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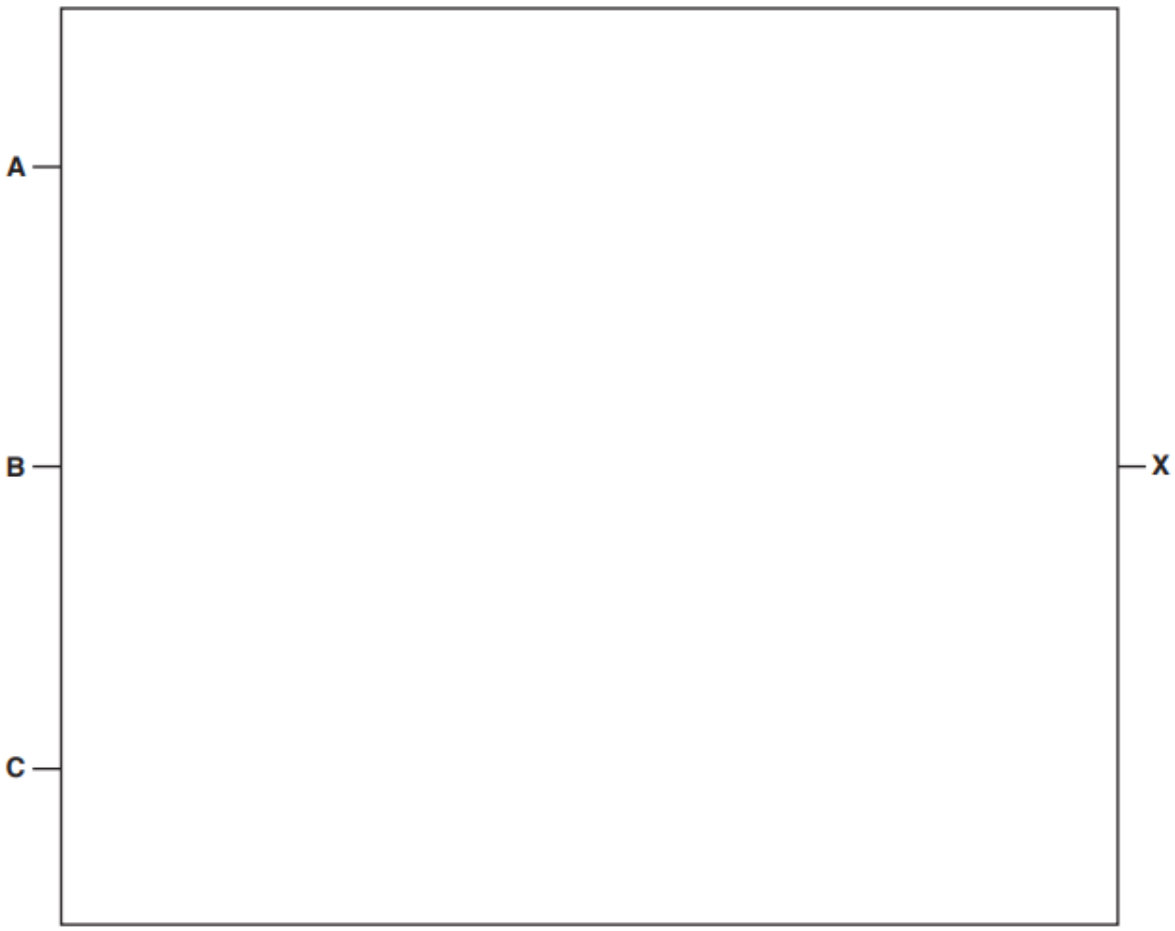
.....[5]

11 Draw a logic circuit to represent the logic statement:

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

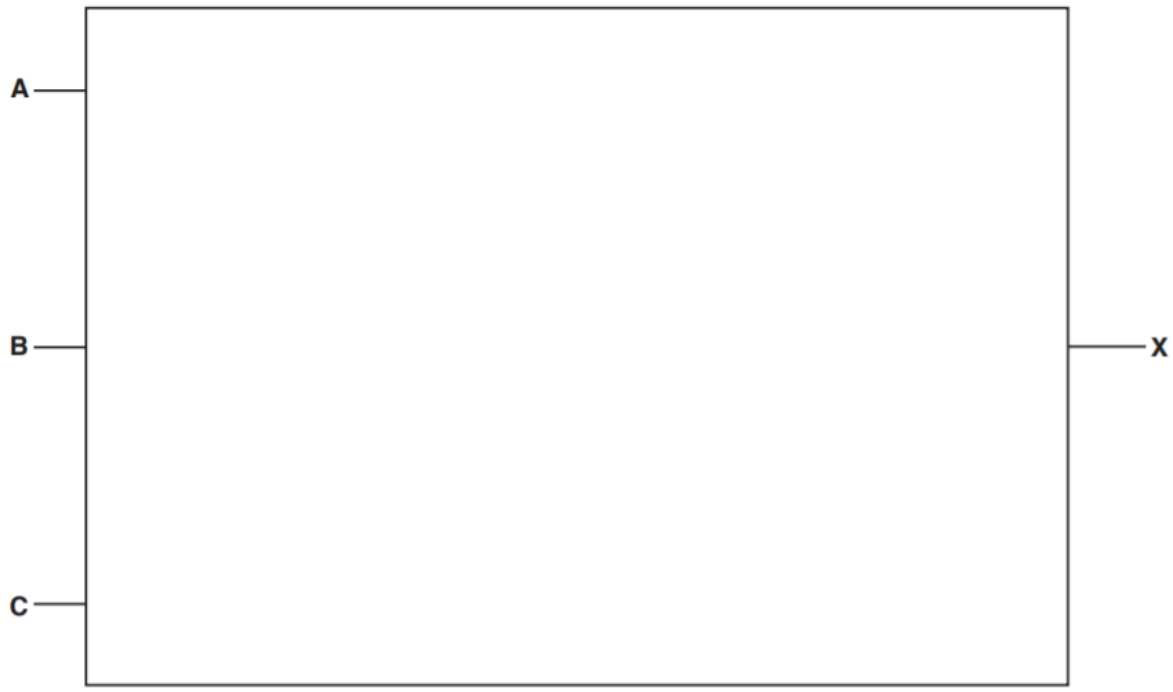


[7]

12 Consider the logic statement:

X = 1 if ((A is NOT 1 OR B is 1) NOR C is 1) NAND ((A is 1 AND C is 1) NOR B is 1)

(a) Draw a logic circuit to represent the given logic statement.



[6]

(b) Complete the truth table for the given 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]

13 Consider the logic statement:

X = 1 if ((A is 1 AND B is NOT 1) NAND C is 1) XOR ((A is 1 AND C is 1) OR B is 1)

(a) Draw a logic circuit to represent the given logic statement.

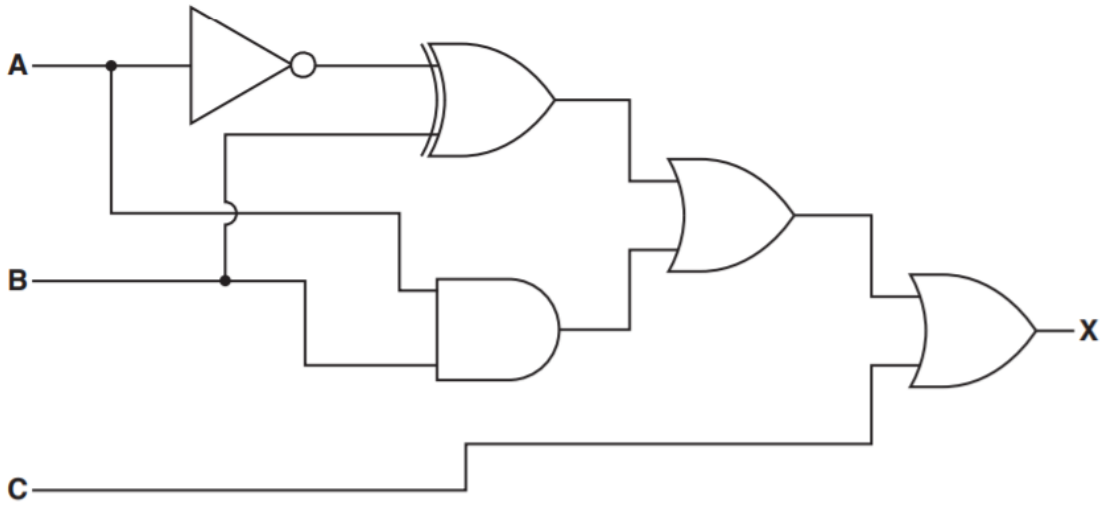
[6]

(b) Complete the truth table for the given 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]

14 A logic circuit is shown below.



(a) 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		

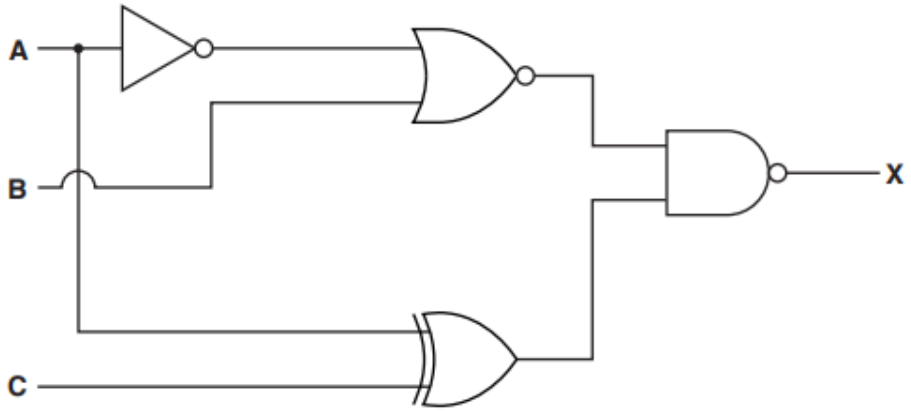
[4]

(b) Draw a logic circuit corresponding to this logic statement:

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

[6]

15 A logic circuit is shown:



(a) 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		

[4]

(b) Explain the difference between the functions of an AND gate and an OR gate.

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..... [3]

16 A greenhouse uses a system to monitor the conditions that plants need to grow.

The inputs to the system are:

Input	Binary value	Condition
W	1	Window is open
	0	Window is closed
T	1	Temperature >=26 °C
	0	Temperature <26 °C
H	1	Humidity >=50%
	0	Humidity <50%

The system will sound an alarm when certain conditions are detected.

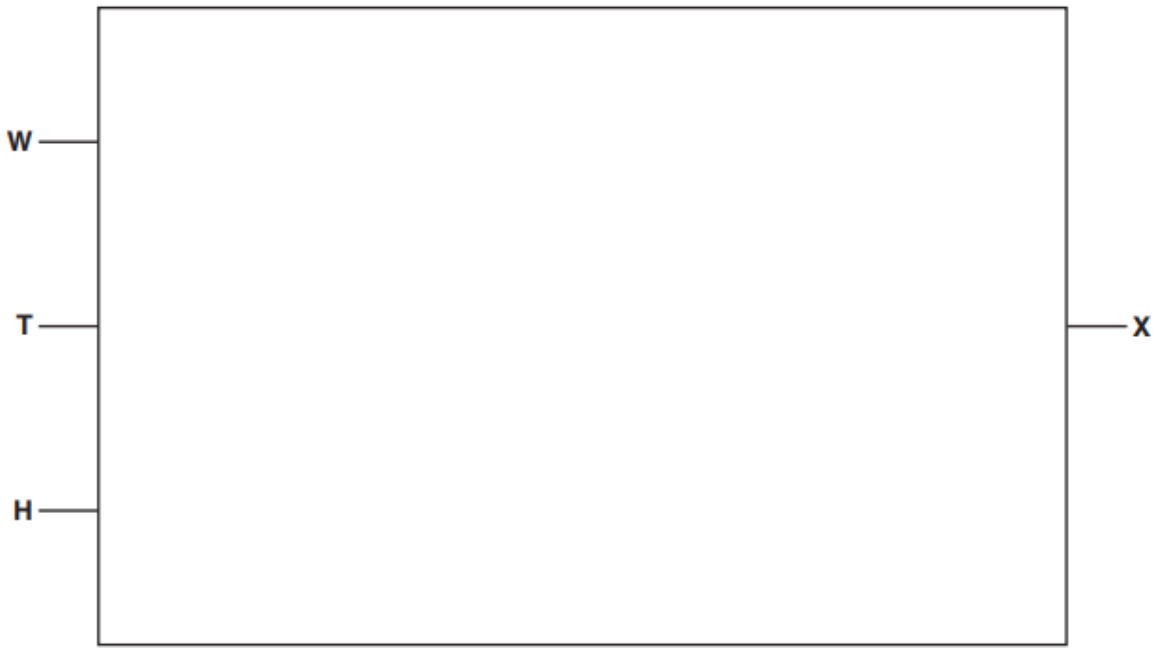
Alarm (X) will sound (=1) when:

window is closed and temperature >=26 °C

or

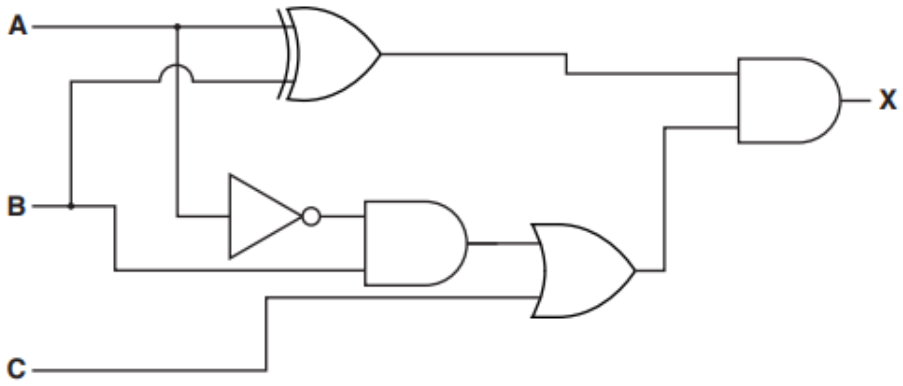
temperature <26 °C and humidity >=50%

Draw a logic circuit to represent the system.



[5]

17 A logic circuit is shown:



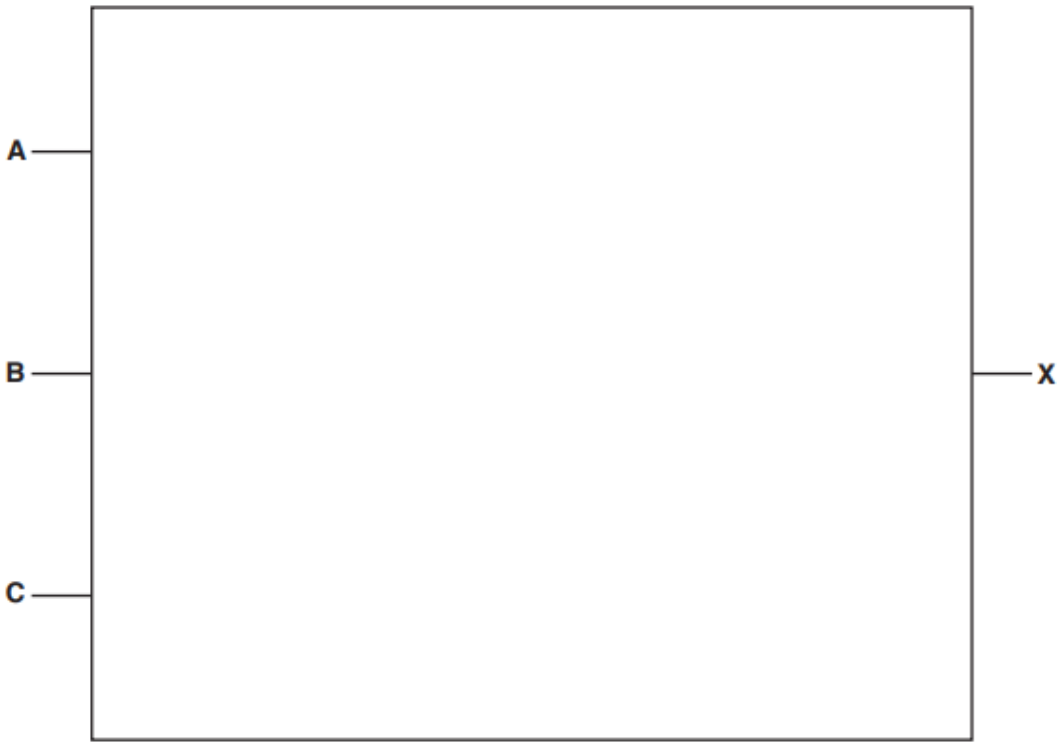
(a) Complete the truth table for the given logic circuit.

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		

[4]

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

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



[6]

18 Rajesh creates a logic circuit.

He uses three different logic gates in his circuit. Each logic gate has a maximum of **two** inputs.

He describes the logic of each gate.

(a) "The only time the output will be 1 is when both inputs are 1."

State the single logic gate .....

Draw the single logic gate:

[2]

(b) "The only time the output will be 1 is when both inputs are 0."

State the single logic gate .....

Draw the single logic gate:

[2]

(c) "The only time the output will be 0 is when both inputs are 1."

State the single logic gate .....

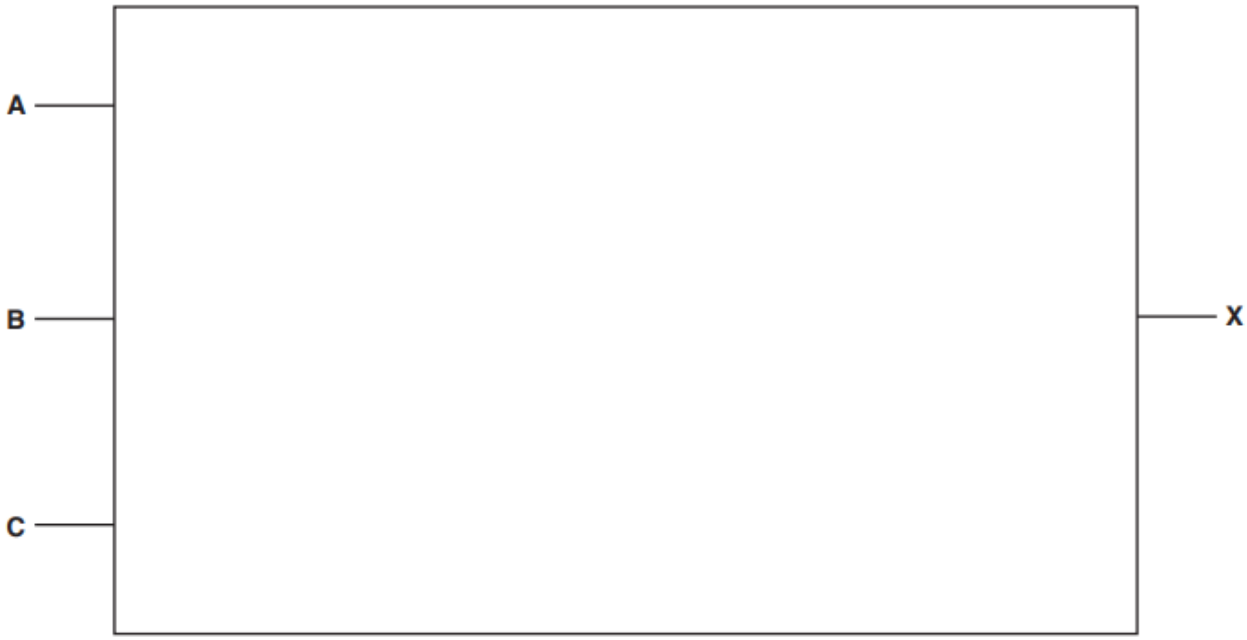
Draw the single logic gate:

[2]

19 Consider the logic statement:

X = 1 if ((A is 1 NOR C is 1) AND (B is NOT 1 NOR C is 1)) OR (A is 1 AND B is 1)

(a) Draw a logic circuit to match the given logic statement. Each logic gate used must have a maximum of **two** inputs. Do **not** attempt to simplify the logic statement.



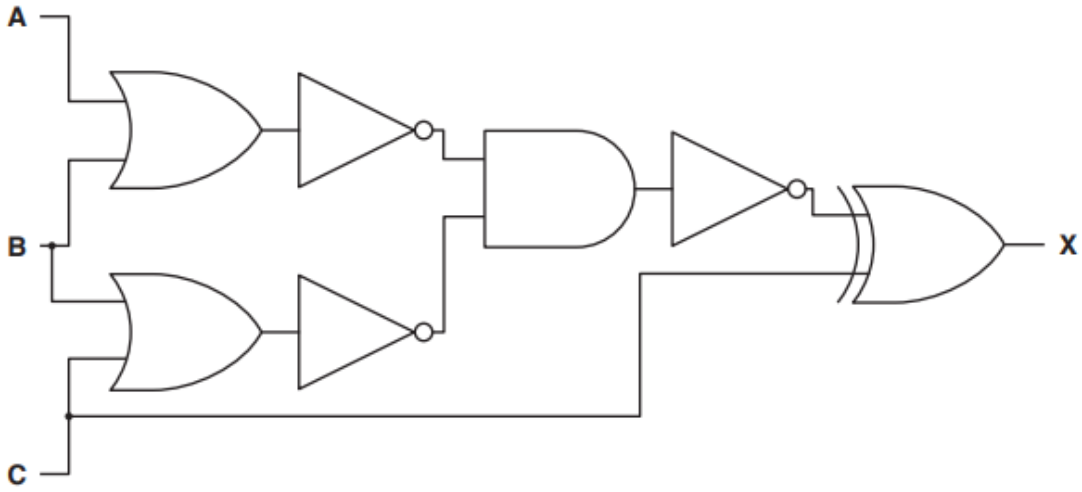
[6]

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

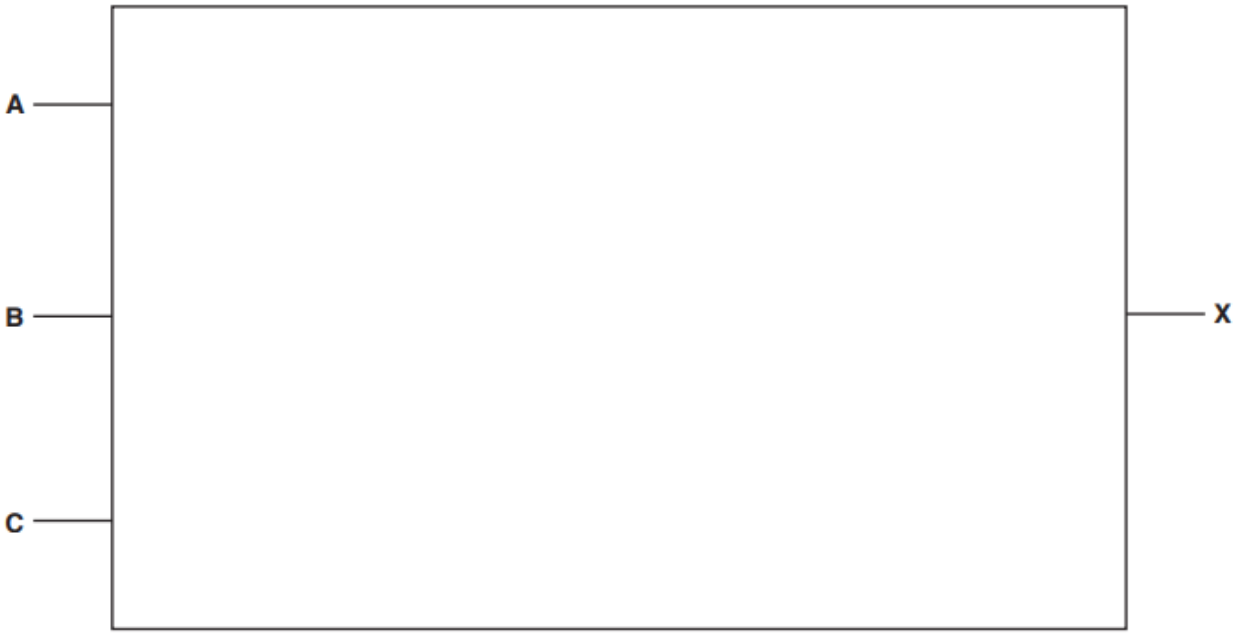
A	B	C	Working space	X
0	0	0		
0	0	1		
0	1	0		
0	1	1		
1	0	0		
1	0	1		
1	1	0		
1	1	1		

[4]

20 Consider the given logic circuit:



(a) Redraw the logic circuit using only 4 logic gates. Each logic gate used must have a maximum of **two** inputs.



[4]

(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		

[4]

(c) Describe the purpose of a logic gate in a logic circuit.

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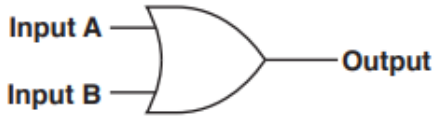
..... [2]

21 A factory manufactures plastic pipes. It uses logic circuits to control the manufacturing process.

(a) Consider the logic gate:



Complete the truth table for this logic gate.

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

[1]

(b) Consider the truth table:

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

State the **single** logic gate that produces the given output.

..... [1]

(c) Plastic pipes of various sizes are manufactured by heating the plastic and using pressure.

The manufacturing system uses sensors to measure the pressure (P), temperature (T) and speed (S) of production.

The inputs to the manufacturing system are:

Input	Binary value	Condition
P	1	pressure is > 5 bar
	0	pressure is <= 5 bar
T	1	temperature is > 200 degrees Celsius
	0	temperature is <= 200 degrees Celsius
S	1	speed is > 1 metre per second
	0	speed is <= 1 metre per second

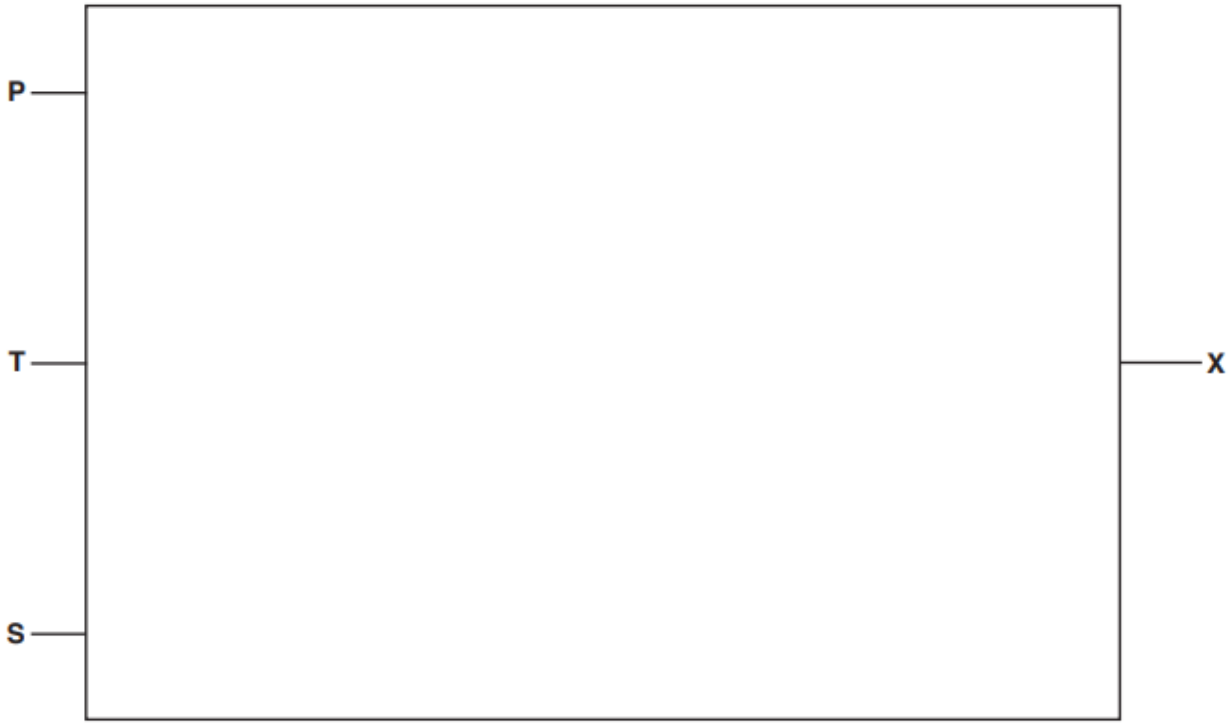
The system will sound an alarm (**X**) when certain conditions are detected.

The alarm will sound when:

Temperature is > 200 degrees Celsius and the pressure is <= 5 bar
or
Speed is > 1 metre per second and Temperature is <= 200 degrees Celsius

Draw a logic circuit to represent the above alarm system.

Logic gates used must have a maximum of **two** inputs.



[5]

(d) Give **two** benefits of using sensors to monitor the manufacture of plastic pipes.

1 .....

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2 .....

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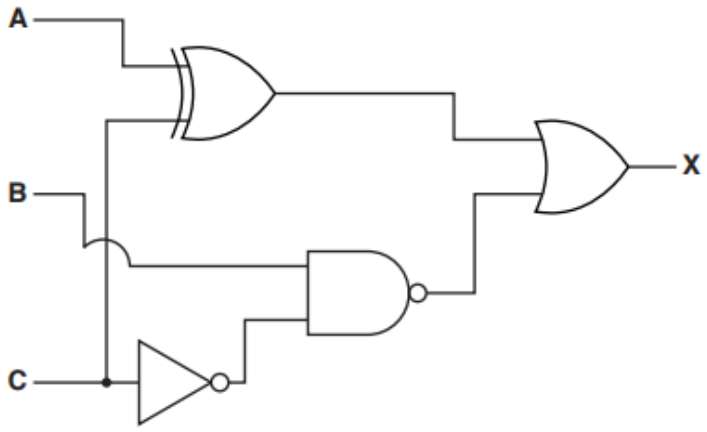
[2]

22 Consider the logic circuit:



(a) Write a logic statement to match the given 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		

[4]

23 A factory that manufactures cleaning products has a system that monitors conditions throughout the manufacturing process.

The inputs to the system are:

Input	Binary value	Condition
A	1	pH > 7
	0	pH < = 7
T	1	Temperature < 35 °C
	0	Temperature > = 35 °C
P	1	Pressure > = 80 %
	0	Pressure < 80 %

(a) The system will sound an alarm (**X**) when certain conditions are detected.

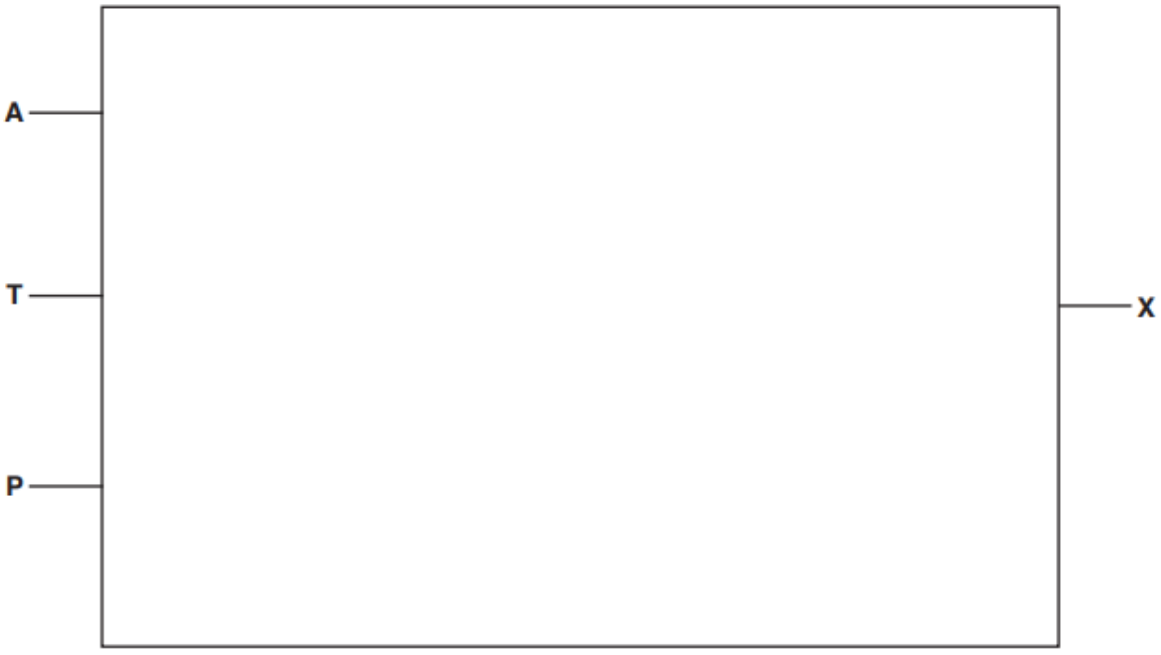
The alarm will sound when:

- The pressure > = 80 % and the temperature > = 35 °C

or

- The temperature < 35 °C and the pH > 7

Draw a logic circuit to represent the alarm system in the factory. Each logic gate must have a maximum of two inputs.



[4]

(b) Complete the truth table for the given logic problem.

A	T	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]

(c) A sensor and a microprocessor are used to monitor the pH of the cleaning products. The system records each reading that is taken. If the reading is greater than 7 a warning message is displayed on a monitor.

Explain how the sensor and microprocessor are used in the system.

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

..... [6]

24 Consider the logic statement:

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

(a) Draw a logic circuit to match the given logic statement.

All logic gates must have a maximum of **two** inputs. Do **not** attempt to simplify the logic statement.

[5]

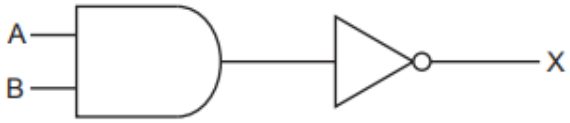
(b) Complete the truth table to represent the given logic statement.

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]

25 **(a)** Identify the name **and** draw the **single** logic gate that can replace the given logic circuits.

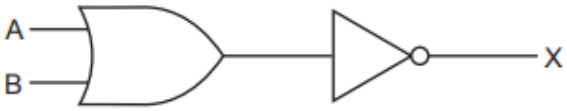
(i)



Name of gate: ..... Drawing of gate:

[2]

(ii)



Name of gate: ..... Drawing of gate:

[2]

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

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

[4]

26 Consider the given logic statement:

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

(a) Draw a logic circuit to match the given logic statement.

All logic gates must have a maximum of **two** inputs. Do **not** attempt to simplify the logic statement.

[4]

(b) Complete the truth table for the given 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		

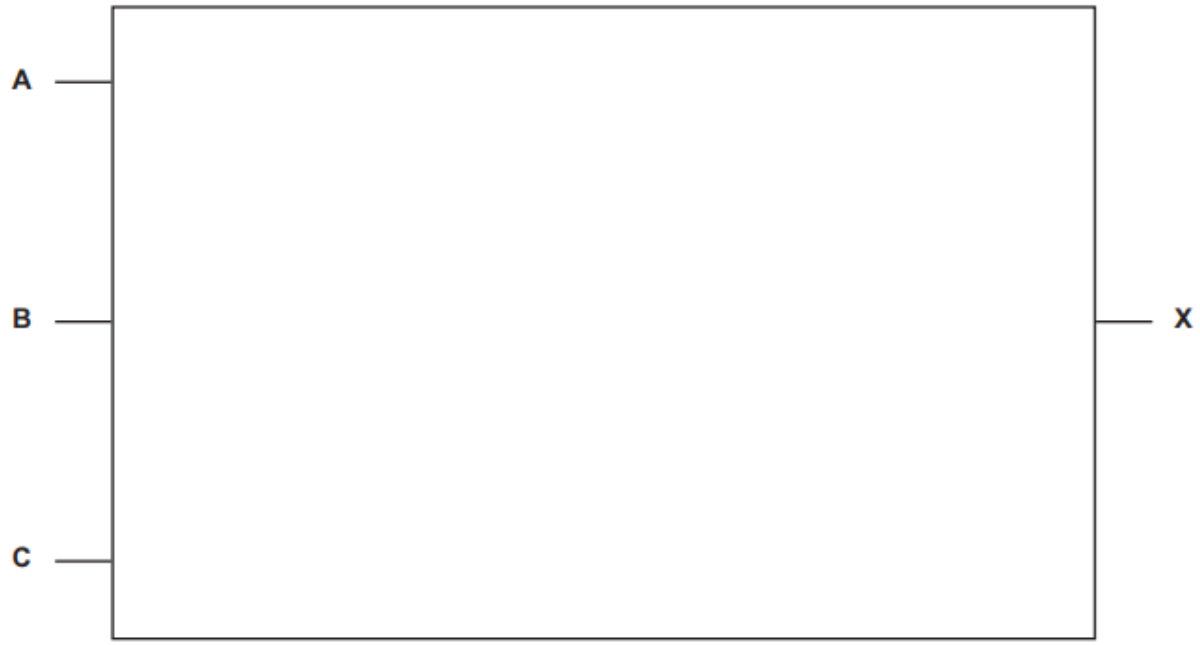
[4]

27 Consider the given logic statement:

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

(a) Draw a logic circuit to represent the given logic statement.

All logic gates must have a maximum of **two** inputs. Do **not** attempt to simplify the logic statement.



[4]

(b) Complete the truth table for the given 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]

(c) The logic statement given has **four** different logic gates.

Identify **two other** logic gates and complete a truth table for each.

Logic gate

.....

Truth table

A	B	X
0	0	
0	1	
1	0	
1	1	

Logic gate

.....

Truth table

A	B	X
0	0	
0	1	
1	0	
1	1	

[4]

28 Consider the logic statement:

X = (((**A** NAND **B**) NOR (**B** AND **C**)) OR **C**)

(a) Draw a logic circuit to match the given logic statement.

All logic gates must have a maximum of **two** inputs. Do **not** attempt to simplify the logic statement.

[4]

(b) Complete the truth table for the given 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		

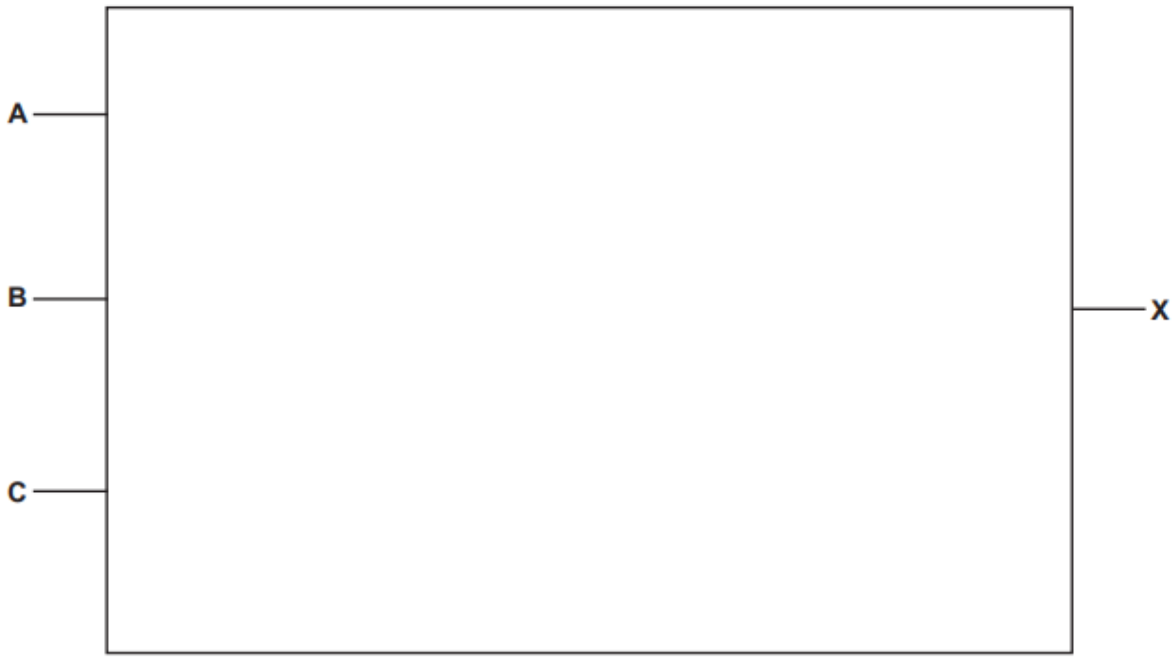
[4]

29 Consider the following logic statement:

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

(a) Draw a logic circuit to match the given logic statement.

All logic gates must have a maximum of **two** inputs. Do **not** attempt to simplify the logic statement.



[4]

(b) Complete the truth table for the given 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		

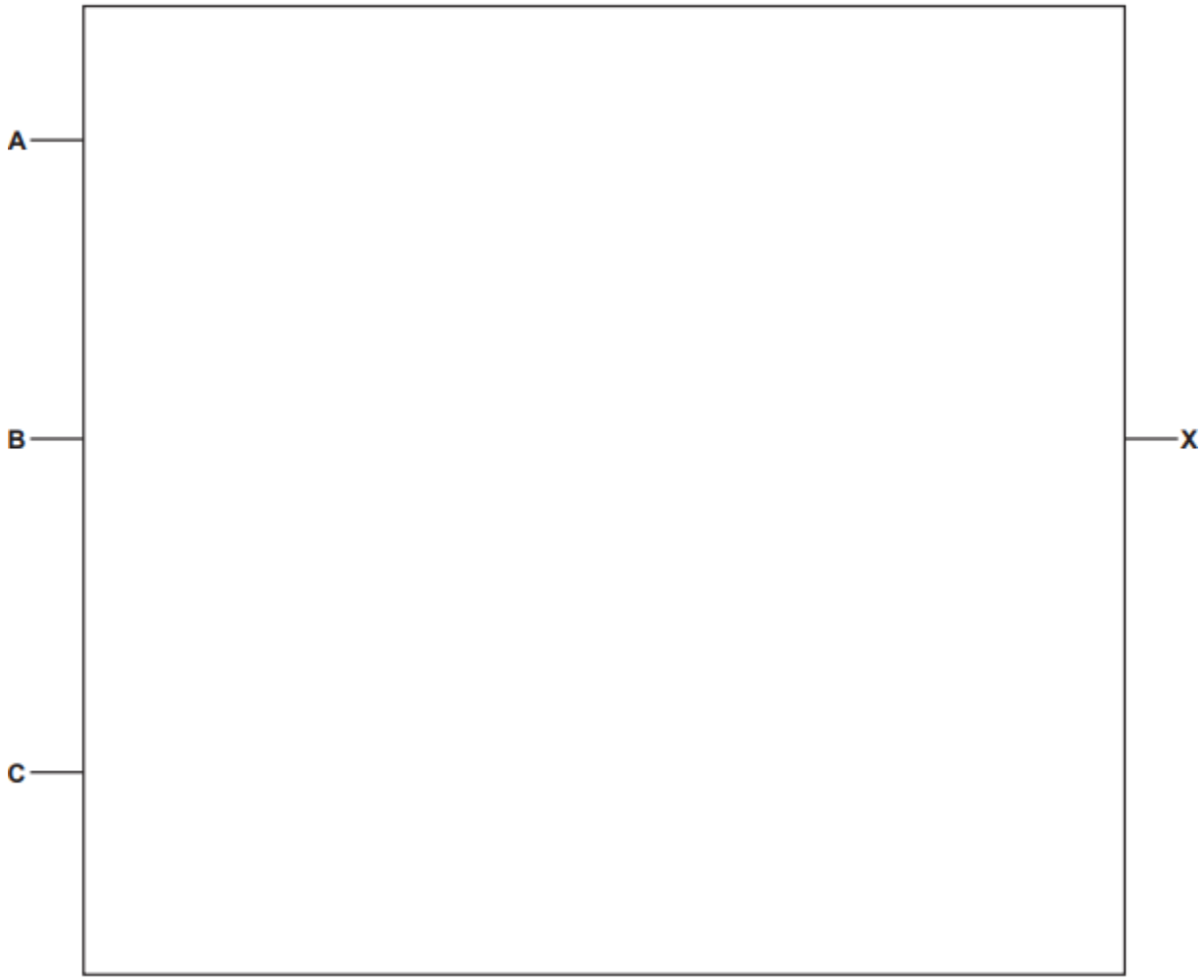
[4]

30 Consider the logic statement:

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

(a) Draw a logic circuit to represent the given logic statement.

Do **not** attempt to simplify the statement. All logic gates must have a maximum of two inputs.



[6]

(b) Consider the completed truth table for the given logic statement.

Row number	A	B	C	Working space	X
1	0	0	0		**0**
2	0	0	1		**1**
3	0	1	0		**0**
4	0	1	1		**1**
5	1	0	0		**0**
6	1	0	1		**1**
7	1	1	0		**0**
8	1	1	1		**1**

There are four errors in the truth table in the output (X) column.

Identify the **four** incorrect outputs.

Write the row number to identify each incorrect output.

Row .....

Row .....

Row .....

Row .....

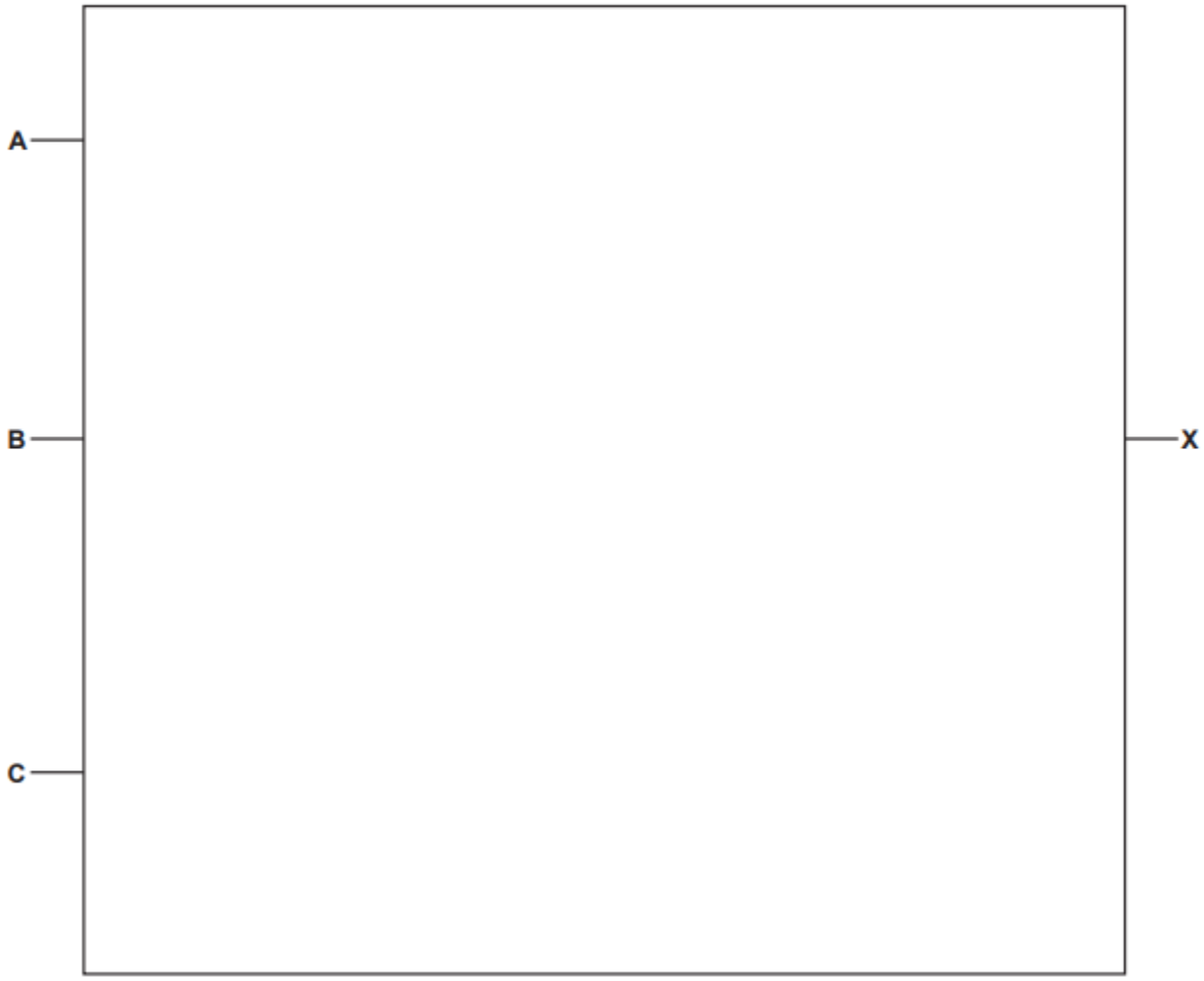
[4]

31 Consider the logic statement:

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

(a) Draw a logic circuit to represent the given logic statement.

Do **not** attempt to simplify the statement. All logic gates must have a maximum of **two** inputs.



[6]

(b) Consider the completed truth table for the given logic statement.

Row number	A	B	C	Working space	X
1	0	0	0		**1**
2	0	0	1		**1**
3	0	1	0		**1**
4	0	1	1		**0**
5	1	0	0		**1**
6	1	0	1		**0**
7	1	1	0		**1**
8	1	1	1		**1**

There are four errors in the truth table in the output (X) column.

Identify the **four** incorrect outputs.

Write the row number to identify each incorrect output.

Row .....

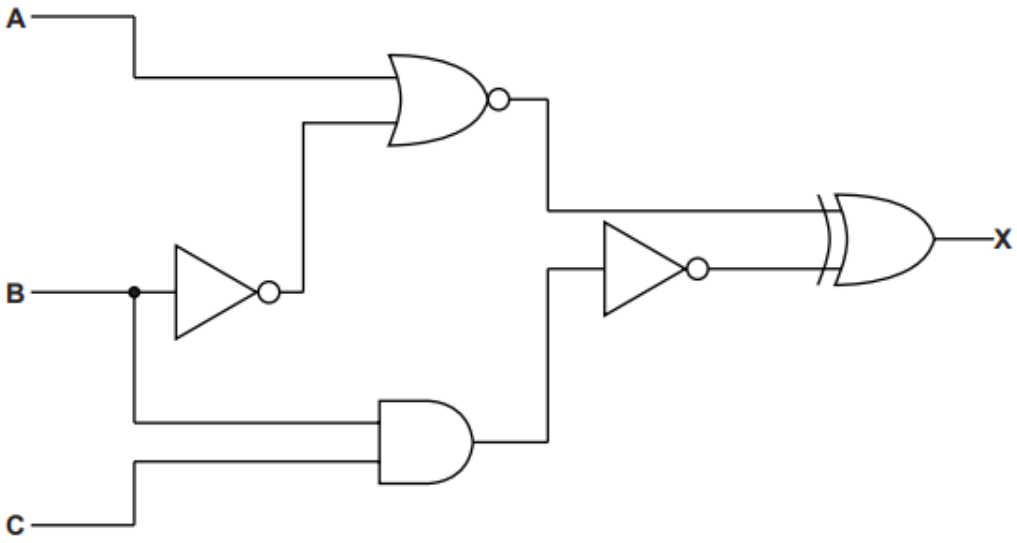
Row .....

Row .....

Row .....

[4]

32 Consider the following logic circuit:



(a) Two **NOT** gates are used in the given logic circuit.

Identify **three** other logic gates that are used in the given logic circuit.

1 .....

2 .....

3 .....

[3]

(b) Consider the completed truth table for the given logic circuit.

Row number	A	B	C	Working space	X
1	0	0	0		**0**
2	0	0	1		**1**
3	0	1	0		**0**
4	0	1	1		**0**
5	1	0	0		**1**
6	1	0	1		**1**
7	1	1	0		**0**
8	1	1	1		**1**

There are four errors in the truth table in the output (X) column.

Identify the **four** incorrect outputs.

Write the row number to identify each incorrect output.

Row .....

Row .....

Row .....

Row .....

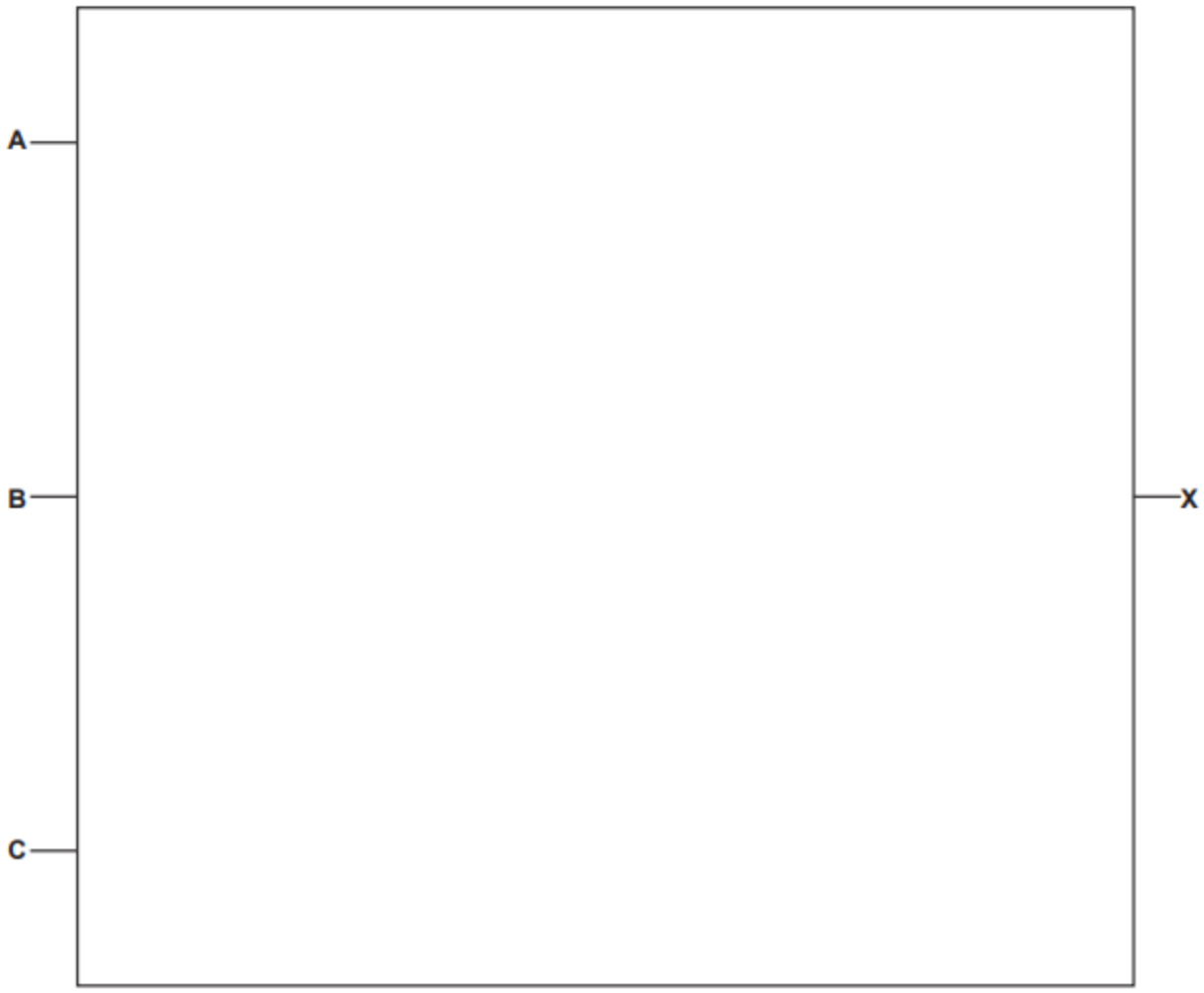
[4]

33 Consider the following logic statement:

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

(a) Draw a logic circuit to represent the given logic statement.

Do **not** attempt to simplify the logic statement. All logic gates must have a maximum of **two** inputs.



[5]

(b) State the name of a logic gate that does **not** appear in the logic statement and draw the symbol for the logic gate.

Name of logic gate ..... Logic gate symbol:

[2]

(c) Complete the truth table for the given 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		

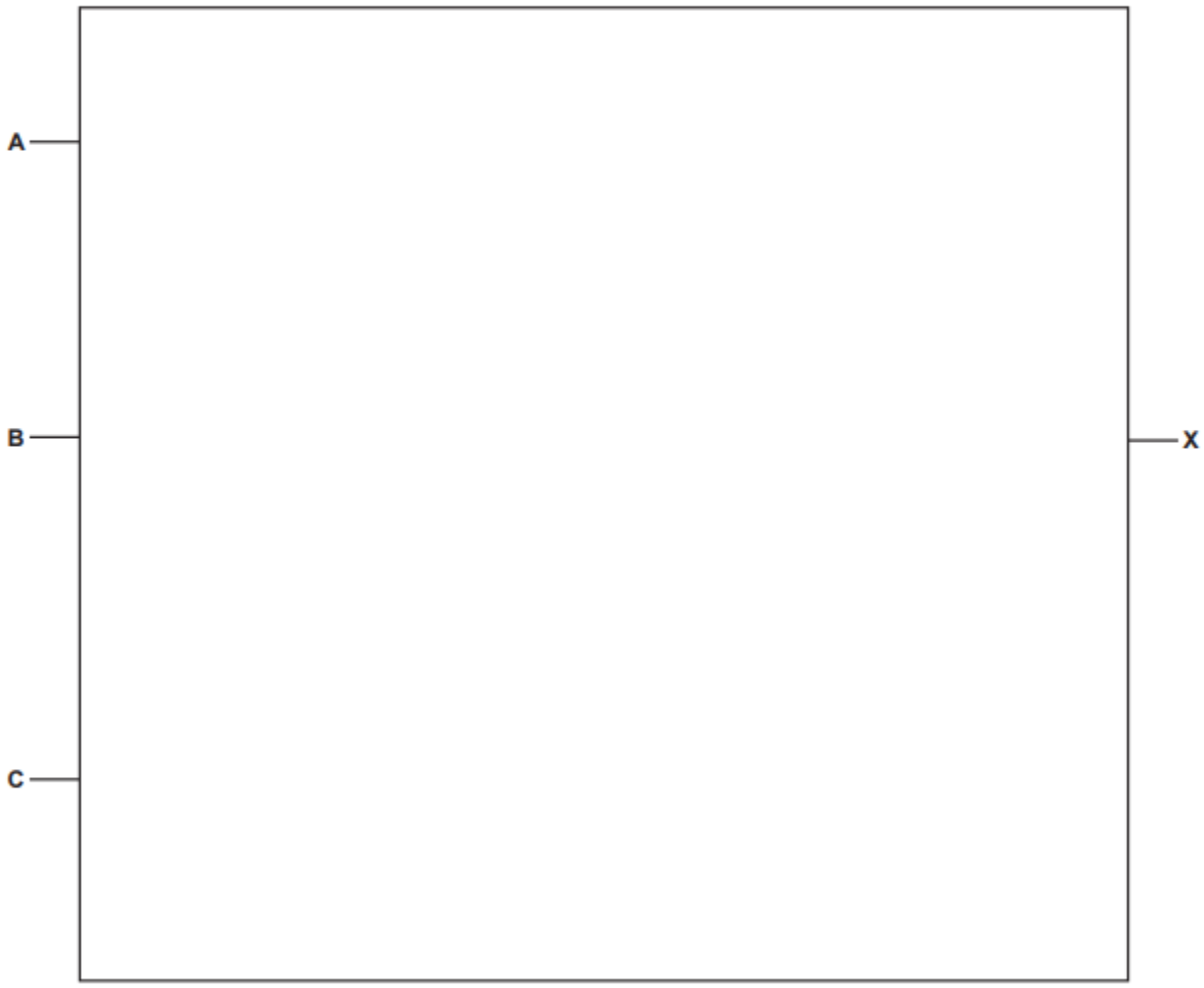
[4]

34 Consider the following logic statement:

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

(a) Draw a logic circuit to represent the given logic statement.

Do **not** attempt to simplify the logic statement. All logic gates must have a maximum of **two** inputs.



[5]

(b) Complete the truth table for the given 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]

(c) Identify **two** logic gates that are **not** included in the given logic statement.

Logic gate 1 .....

Logic gate 2 .....

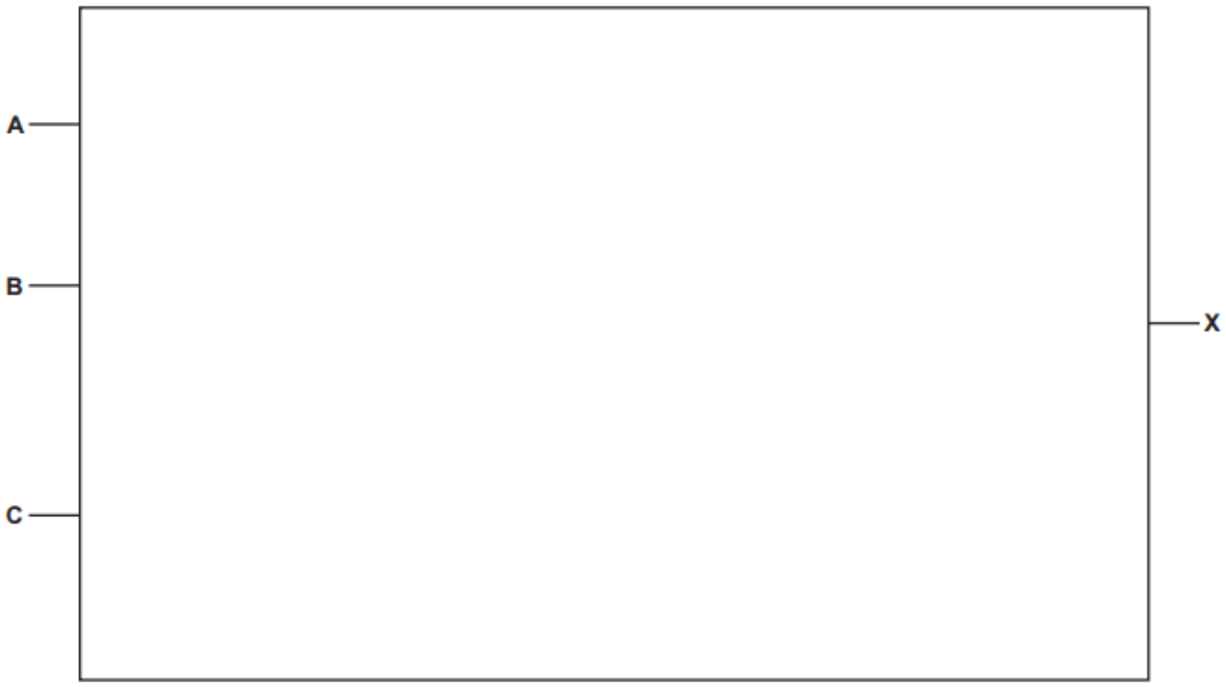
[2]

35 Consider the following logic statement:

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

(a) Draw a logic circuit to represent the given logic statement.

Do **not** attempt to simplify the logic statement. All logic gates must have a maximum of **two** inputs.



[6]

(b) Complete the truth table for the given 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		

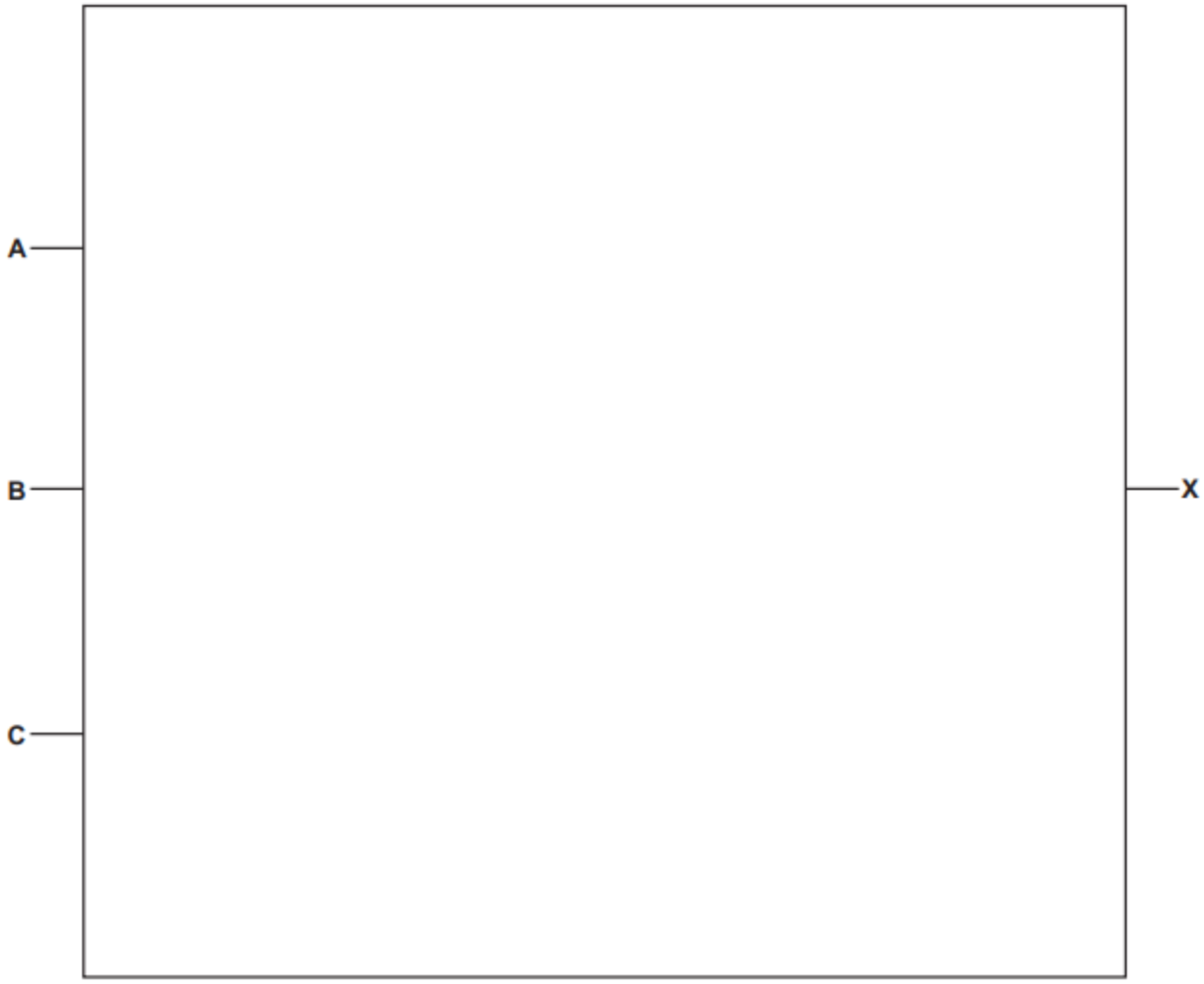
[4]

36 Consider the following logic statement:

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

(a) Draw a logic circuit to represent the given logic statement.

Do **not** attempt to simplify the logic statement. All logic gates must have a maximum of **two** inputs.



[6]

(b) Complete the truth table for the given 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		

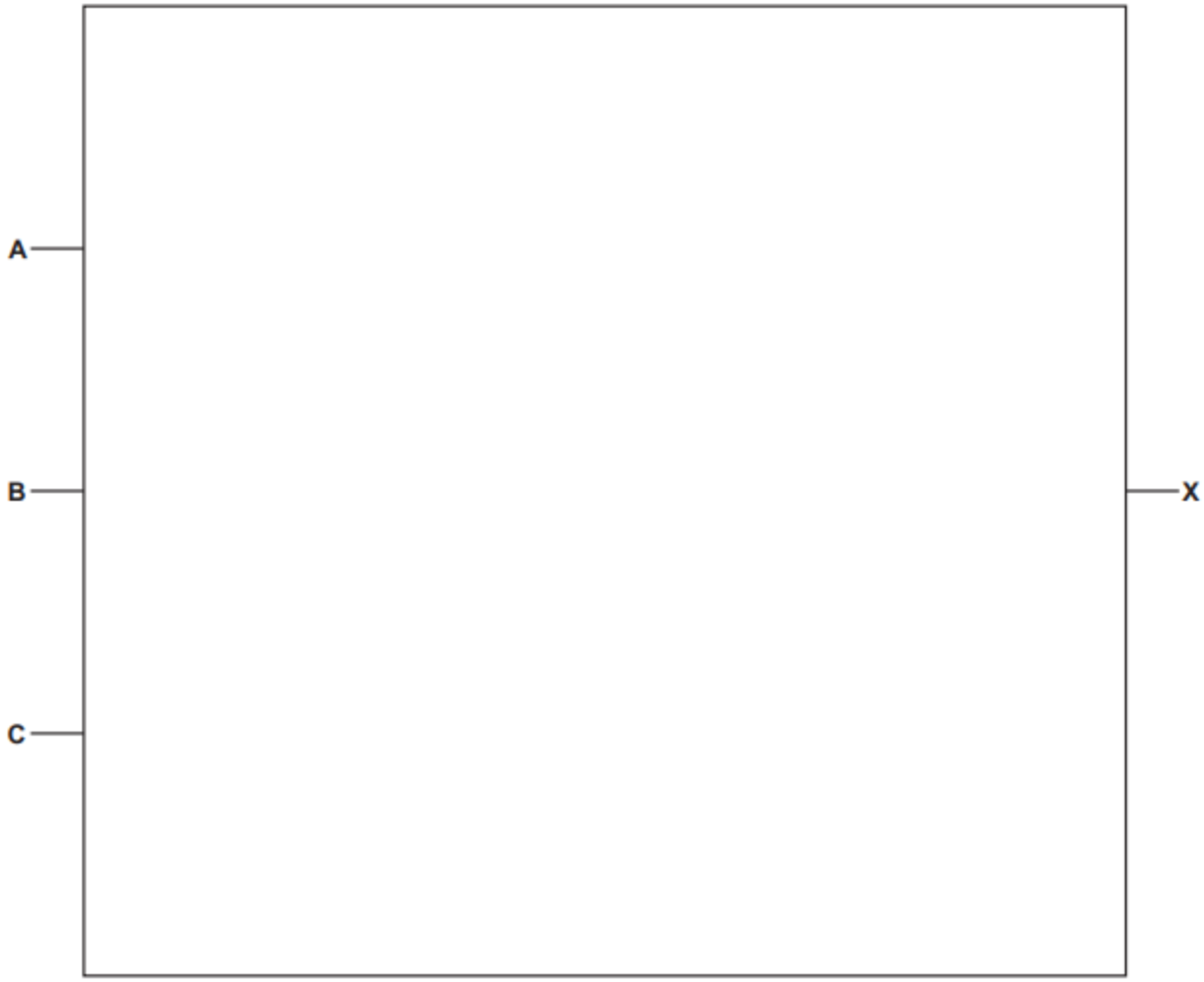
[4]

37 Consider the following logic statement:

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

(a) Draw a logic circuit to represent the given logic statement.

Do **not** attempt to simplify the logic statement. All logic gates must have a maximum of **two** inputs.



[5]

(b) Complete the truth table for the given 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]

38 AND, OR and XOR are three examples of logic gates.

(a) **Four** statements are given about these logic gates.

Tick (✓) to show which statements apply to each logic gate. Some statements may apply to more than **one** logic gate.

Statement	AND (✓)	OR (✓)	XOR (✓)
if both inputs are 0, the output is 0			
if both inputs are different, the output is 1			
if both inputs are 1, the output is 1			
if both inputs are the same, the output is always 0			

[4]

(b) NOT, AND, OR and XOR are all examples of logic gates.

State the name of **two** other logic gates and complete a truth table for each.

Logic gate 1 .....

Truth table:

A	B	Output
0	0	
0	1	
1	0	
1	1	

Logic gate 2 .....

Truth table:

A	B	Output
0	0	
0	1	
1	0	
1	1	

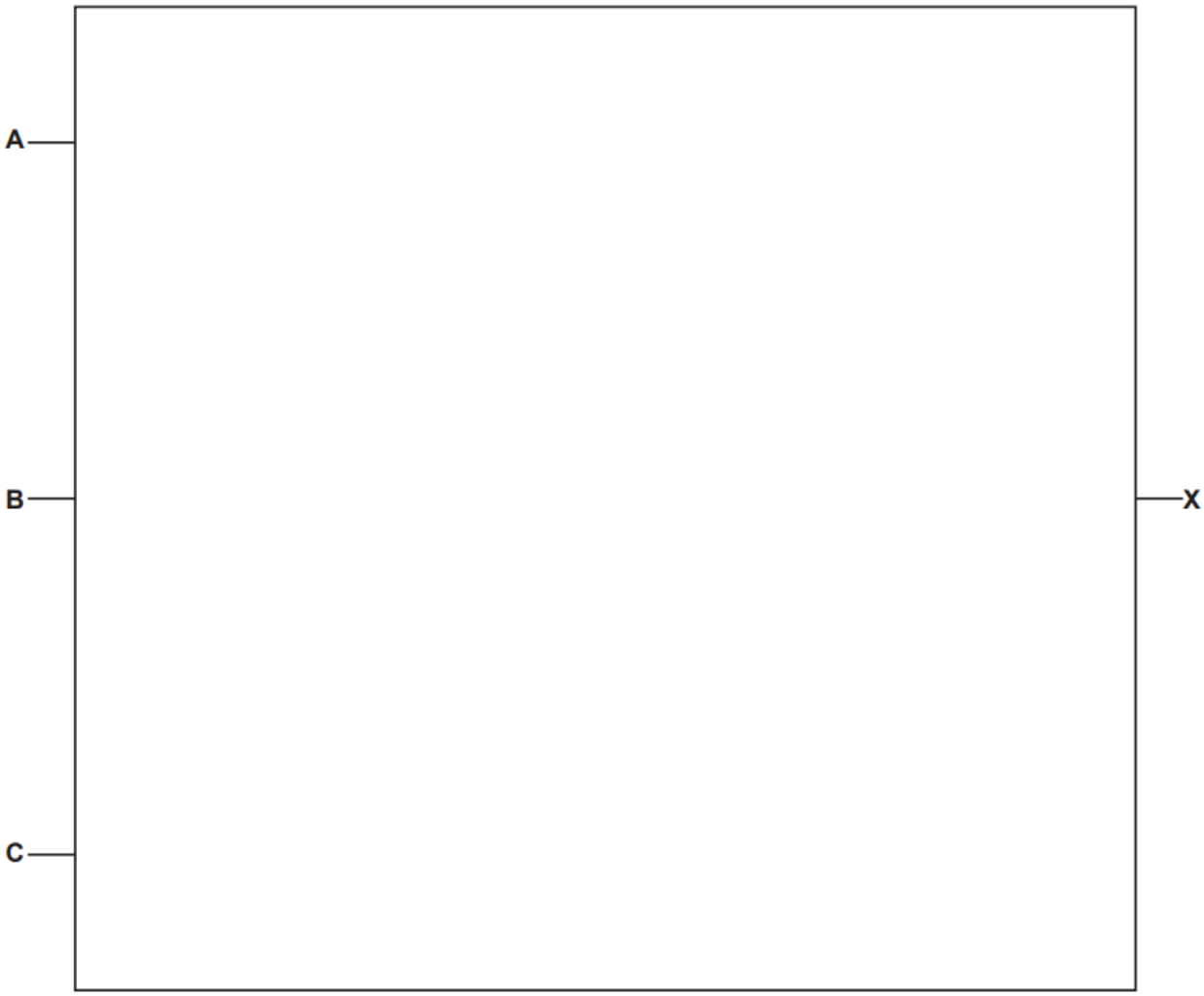
[4]

39 Consider the logic statement:

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

(a) Draw a logic circuit to represent the given logic statement.

Do **not** attempt to simplify the logic statement. All logic gates must have a maximum of **two** inputs.



[6]

(b) State the name of **one** logic gate that is **not** included in the given logic statement.

..... [1]

(c) Complete the truth table for the given 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]

40 NAND, OR and XOR are three types of logic gate.

(a) **Four** statements are shown about the logic gates.

Tick (✓) to show which statements apply to each logic gate. Some statements may apply to more than one logic gate.

Statement	NAND (✓)	OR (✓)	XOR (✓)
if both inputs are 1, the output is 1			
if both inputs are different from each other, the output is 1			
if both inputs are 0, the output is 0			
if both inputs are the same as each other, the output is always 0			

[4]

(b) NAND, OR, XOR, NOR and NOT are all examples of logic gates.

State the name of **one** other logic gate and complete its truth table.

Logic gate .....

Truth table:

A	B	Output
0	0	
0	1	
1	0	
1	1	

[2]

41 Consider the logic statement:

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

(a) Draw a logic circuit to represent the given logic statement.

Do **not** attempt to simplify the logic statement. All logic gates must have a maximum of **two** inputs.

[6]

(b) Complete the truth table for the given 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]

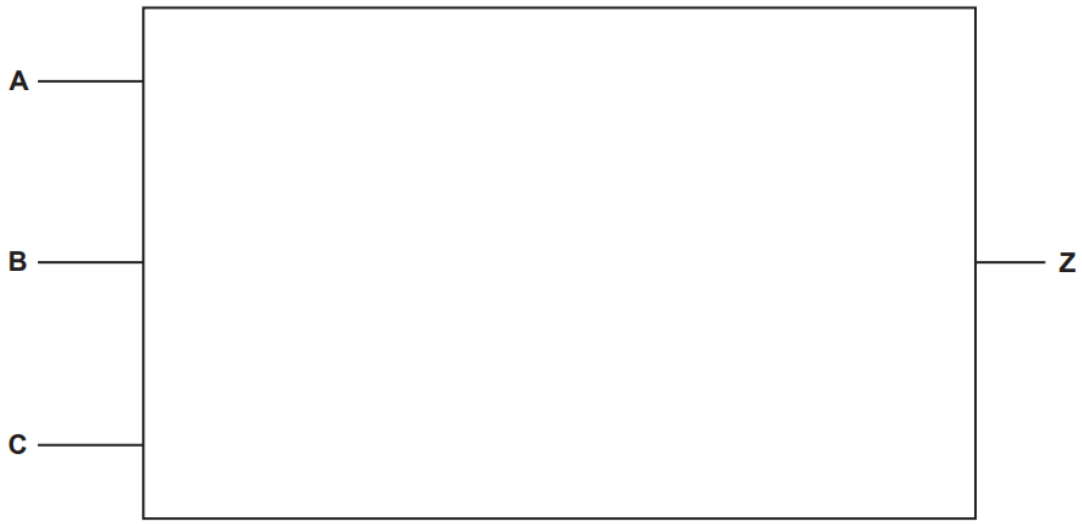
42 Consider this logic expression.

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

(a) Draw a logic circuit for this logic expression.

Each logic gate must have a maximum of **two** inputs.

Do **not** simplify this logic expression.



[4]

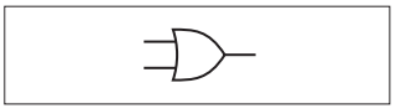
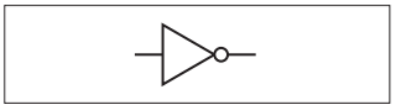
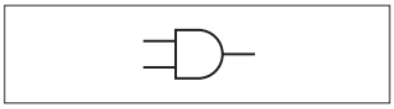
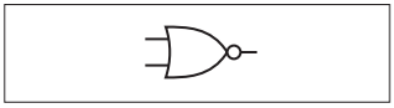
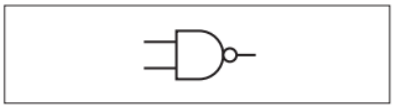
(b) Complete the truth table from the given logic expression.

A	B	C	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		

[4]

43 **Four** logic gates and **five** standard symbols for logic gates are shown.

Draw **one** line to link each logic gate to its standard symbol. **Not** all standard symbols will be used.

Logic gate	Standard symbol
AND	
OR	
NAND	
NOT	
	

[4]

44 Consider this logic expression.

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

Complete the truth table for this logic expression.

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]

45 Consider the logic expression:

Z is 1 if (**A** = 1 AND **C** = NOT 1) AND (**B** = 1 NOR **C** = 1)

(a) Draw a logic circuit for this logic expression.

Each logic gate must have a maximum of **two** inputs.

Do **not** simplify this logic expression.

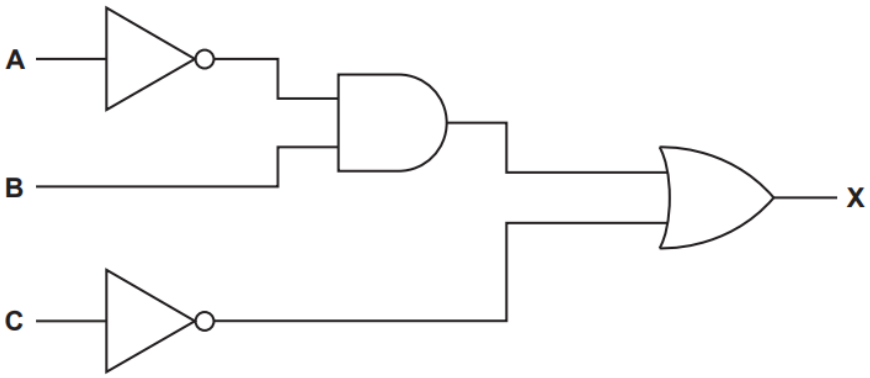
[4]

(b) Complete the truth table from the given logic expression.

A	B	C	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		

[4]

46 Consider this logic circuit.



(a) Write a logic expression for this logic circuit. Do **not** attempt to simplify this logic expression.

X = ...

.....

[4]

(b) Complete the truth table from 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		

[4]

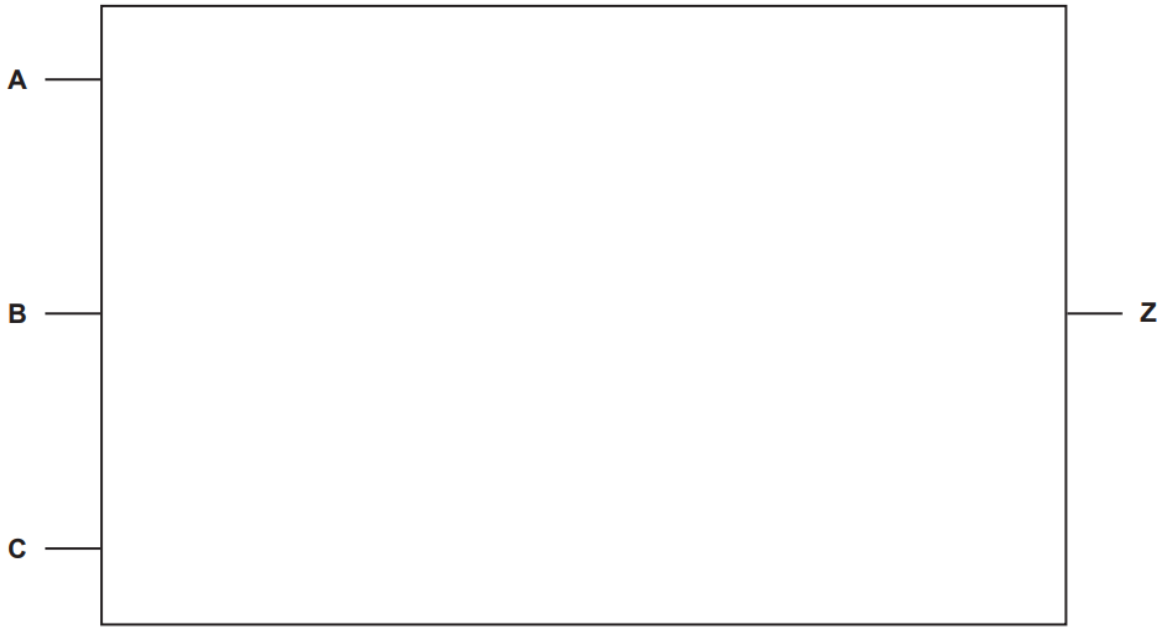
47 Consider the logic expression:

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

(a) Draw a logic circuit for this logic expression.

Each logic gate must have a maximum of **two** inputs.

Do **not** simplify this logic expression.



[4]

(b) Complete the truth table from the given logic expression.

A	B	C	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		

[4]

48 There are **three** descriptions of logic gates. Each logic gate has two inputs **A** and **B** with one output **X**.
Identify each logic gate.
Complete a truth table for each logic gate.

(a) The only time the output is 1 is when both inputs are 1.

Logic gate .....

Complete the truth table for this description.

A	B	X
0	0	
0	1	
1	0	
1	1	

[2]

(b) The output is 1 when both inputs are different.

Logic gate .....

Complete the truth table for this description.

A	B	X
0	0	
0	1	
1	0	
1	1	

[2]

(c) The only time the output is 1 is when both inputs are 0.

Logic gate .....

Complete the truth table for this description.

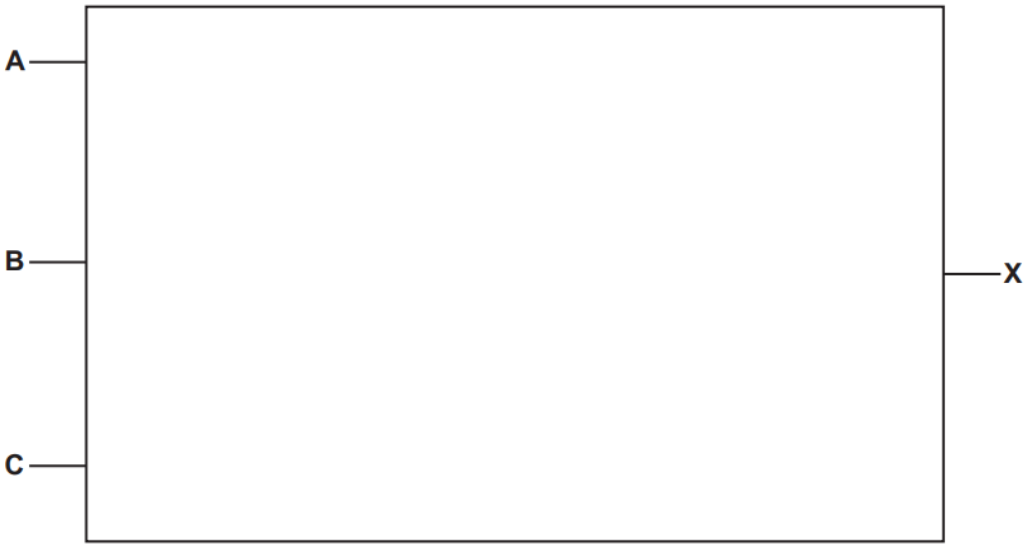
A	B	X
0	0	
0	1	
1	0	
1	1	

[2]

(d) Consider this logic expression:

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

Draw a logic circuit for this logic expression. Each logic gate must have a maximum of **two** inputs. Do **not** attempt to simplify this logic expression.



[5]

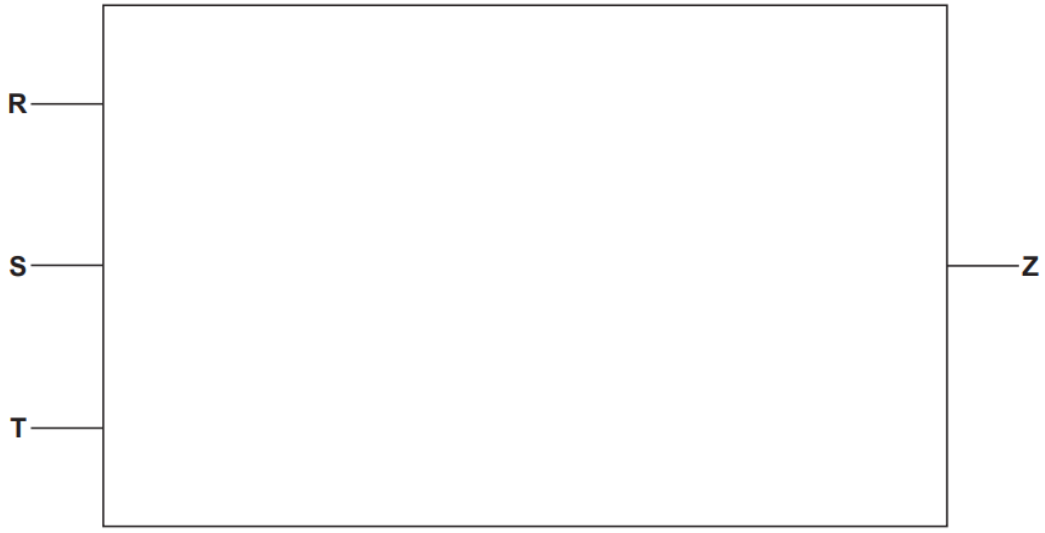
49 Consider the logic expression:

Z = (**R** OR NOT **T**) XOR (NOT **S** AND **T**)

(a) Draw a logic circuit for this logic expression.

Each logic gate must have a maximum of **two** inputs.

Do **not** simplify this logic expression.



[5]

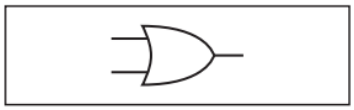
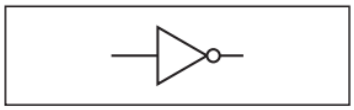
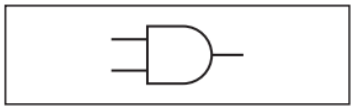
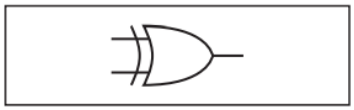
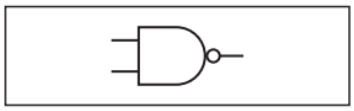
(b) Complete the truth table from the given logic expression.

R	S	T	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		

[4]

50 **Four** logic functions and **five** standard symbols for logic gates are shown.

Draw **one** line to link each logic function to its standard symbol. **Not** all standard symbols will be used.

Logic function	Standard symbol
AND	
XOR	
NAND	
OR	
	

[4]

51 A logic circuit is to be built to control the opening of a safe used to store money. There are two keys, **A** and **B**, and a time switch **C**. The safe can only open if both keys are used and the time switch is off.

key **A**	not used	0
	used	1
key **B**	not used	0
	used	1
time switch **C**	switch off	0
	switch on	1
safe **X**	safe cannot open	0
	safe can open	1

(a) Write the logic expression for this problem.

..... [3]

(b) Complete the truth table for this problem.

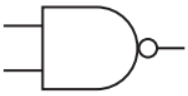
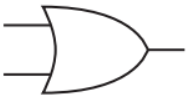
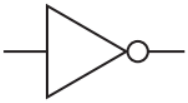
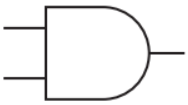
A	**B**	**C**	**Working space**	**X**
0	0	0		
0	0	1		
0	1	0		
0	1	1		
1	0	0		
1	0	1		
1	1	0		
1	1	1		

[4]

52 **(a)** **Four** logic gate symbols and **five** logic functions are shown.

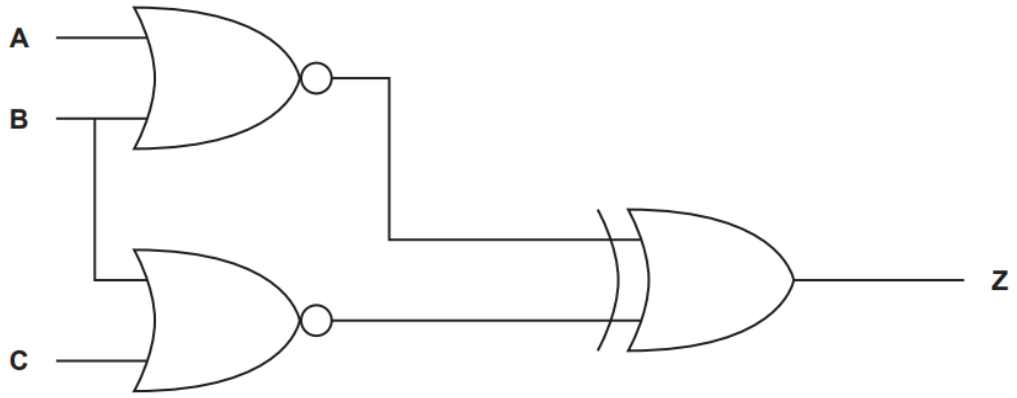
Draw **one** line to link each logic gate symbol to the appropriate logic function.

Not all logic functions will be used.

Logic gate symbol	**Logic function**
	AND
	XOR
	NOT
	NAND
	OR

[4]

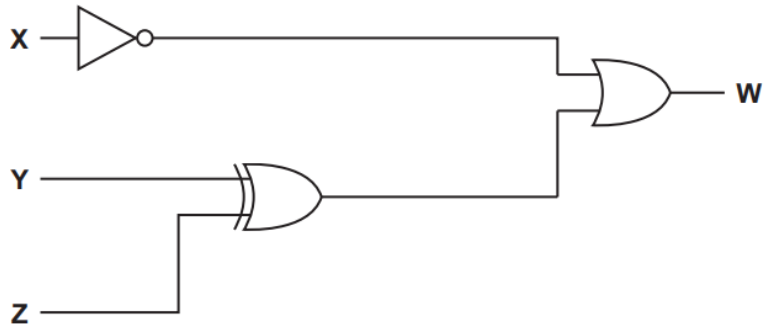
(b) Complete the truth table for this logic circuit.



A	B	C	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		

[4]

53 Consider the logic circuit:



(a) Write a logic expression for the given logic circuit. Do **not** attempt to simplify the logic expression.

W = ...

..... [3]

(b) Complete the truth table from the given logic circuit.

X	Y	Z	Working space	W
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]

54 Consider the logic expression:

X = (NOT **P** OR **Q**) NAND (**Q** XOR **R**)

(a) Draw a logic circuit for this logic expression.

Each logic gate must have a maximum of **two** inputs.

Do **not** simplify the logic expression.

[4]

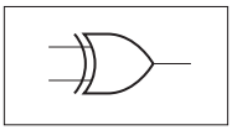
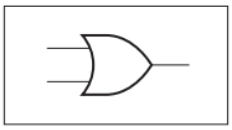
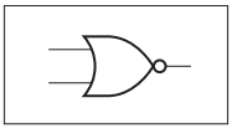
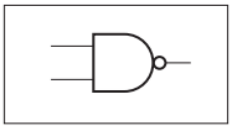
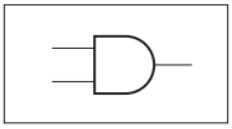
(b) Complete the truth table for the given logic expression.

P	Q	R	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]

55 **Four** logic gates and **five** logic gate symbols are shown.

Draw **one** line to link each logic gate to its correct symbol. **Not** all logic gate symbols will be used.

Logic gate	Logic gate symbol
AND	
NAND	
NOR	
XOR	
	

[4]