10 Boolean Logic
QUESTIONS

10 – Boolean logic

10 – Boolean logic				
1	Identify and use the standard symbols for logic gates			
2	Define and understand the functions of the logic gates			
3	(a) Use logic gates to create given logic circuits from a: (i) problem statement (ii) logic expression (iii) truth table			
3	(b) Complete a truth table from a: (i) problem statement (ii) logic expression (iii) logic circuit			
3	(c) Write a logic expression from a: (i) problem statement (ii) logic circuit (iii) truth table			

More Guidance

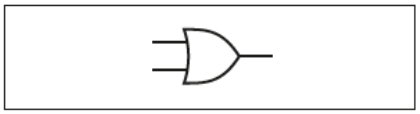
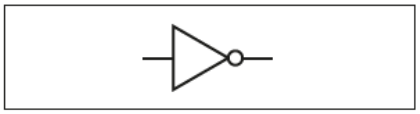
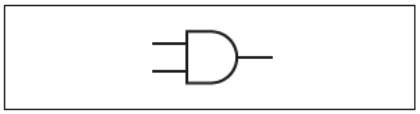
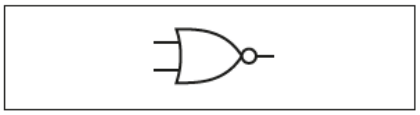
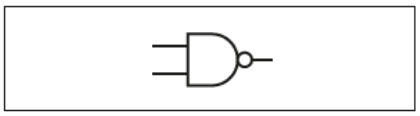
Candidates should be able to:	Notes and guidance
1 Identify and use the standard symbols for logic gates	• See section 4 for logic gate symbols
2 Define and understand the functions of the logic gates	• Including: – NOT – AND – OR – NAND – NOR – XOR (EOR) – the binary output produced from all the possible binary inputs • NOT is a single input gate • All other gates are limited to two inputs
3 (a) Use logic gates to create given logic circuits from a: (i) problem statement (ii) logic expression (iii) truth table	• Circuits must be drawn for the statement given, without simplification • Logic circuits will be limited to a maximum of three inputs and one output
(b) Complete a truth table from a: (i) problem statement (ii) logic expression (iii) logic circuit	• An example truth table with three inputs, for completion:

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

(c) Write a logic expression from a:
(i) problem statement
(ii) logic circuit
(iii) truth table

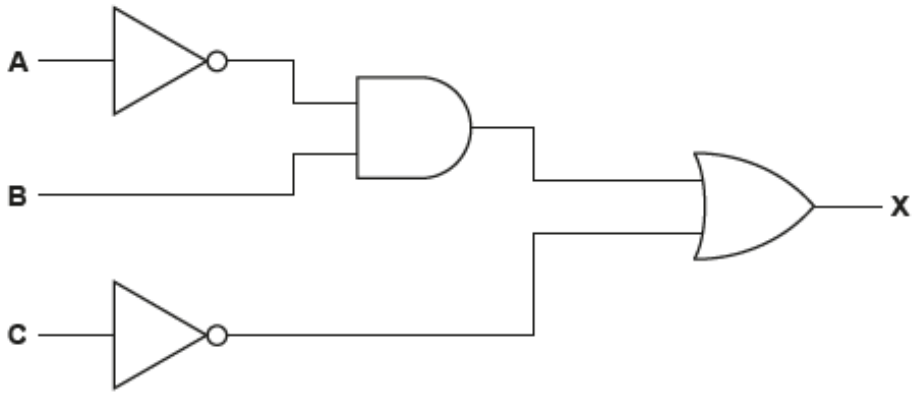
2 **Four** logic gates and **five** standard symbols for logic gates are shown.

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]

7 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]

10 Boolean Logic
QUESTIONS

9 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]

10 Boolean Logic
QUESTIONS

6 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.

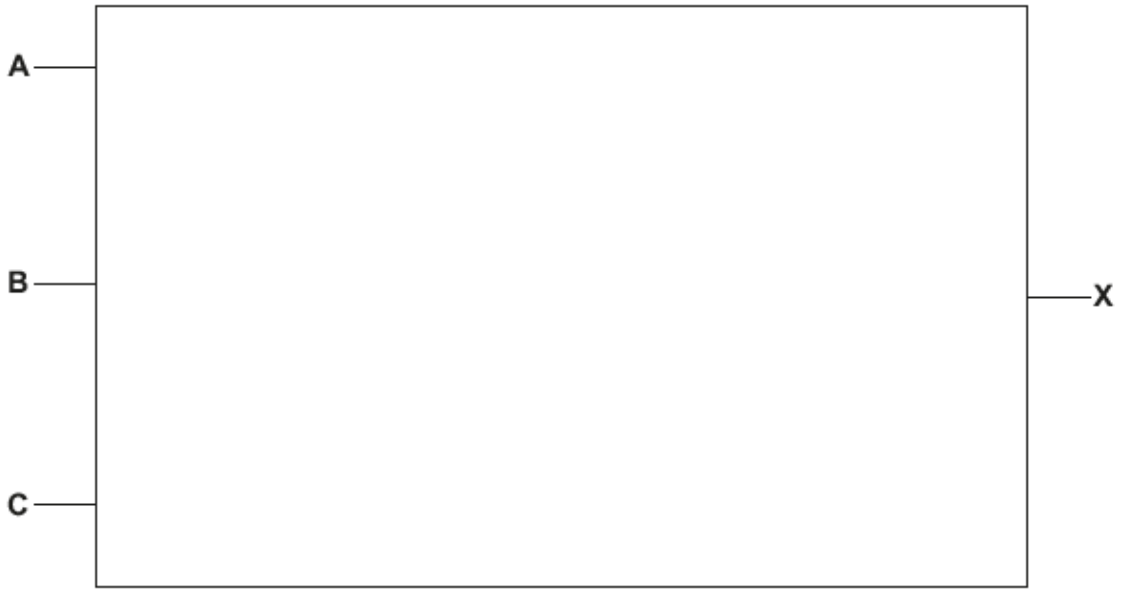
A	B	X
0	0	
0	1	
1	0	
1	1	

[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]

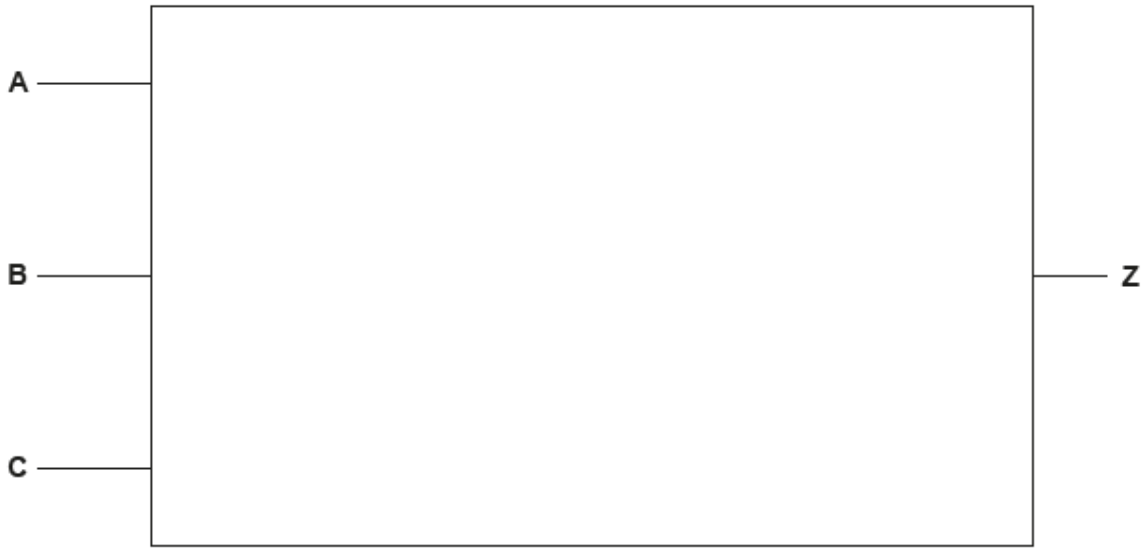
9 Consider this logic expression.

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]

8 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]

10 Boolean Logic
QUESTIONS

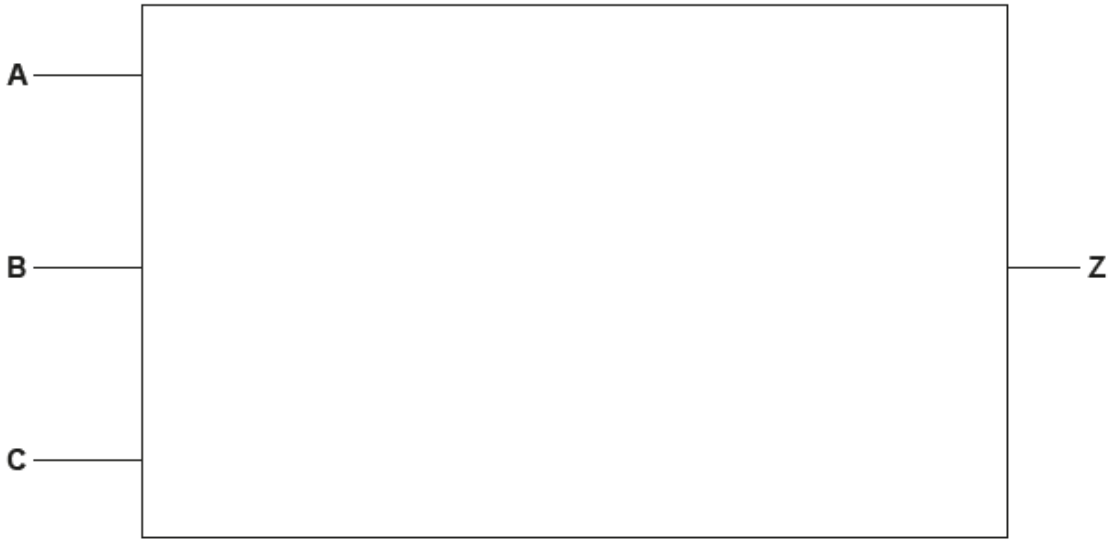
8 Consider the logic expression:

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]

10 Boolean Logic
QUESTIONS

Computers use logic gates.

(a) State the **single** logic gate that produces each truth table.

Truth table	Logic gate
<table><tr><th>A</th><th>B</th><th>Output</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>	.....
<table><tr><th>A</th><th>B</th><th>Output</th></tr><tr><td>0</td><td>0</td><td>0</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>	.....
<table><tr><th>A</th><th>B</th><th>Output</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>	.....

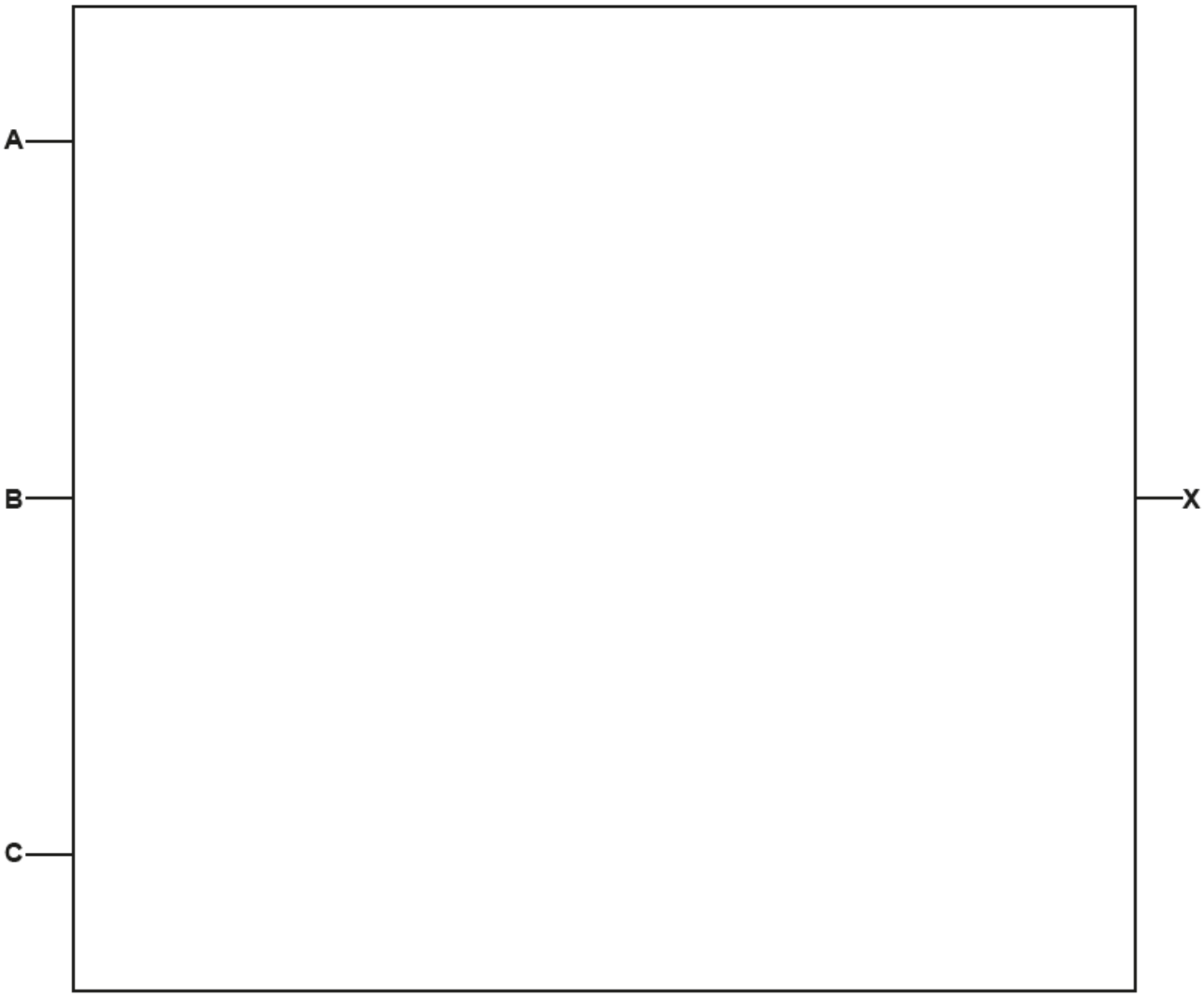
[3]

5 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]

7 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	

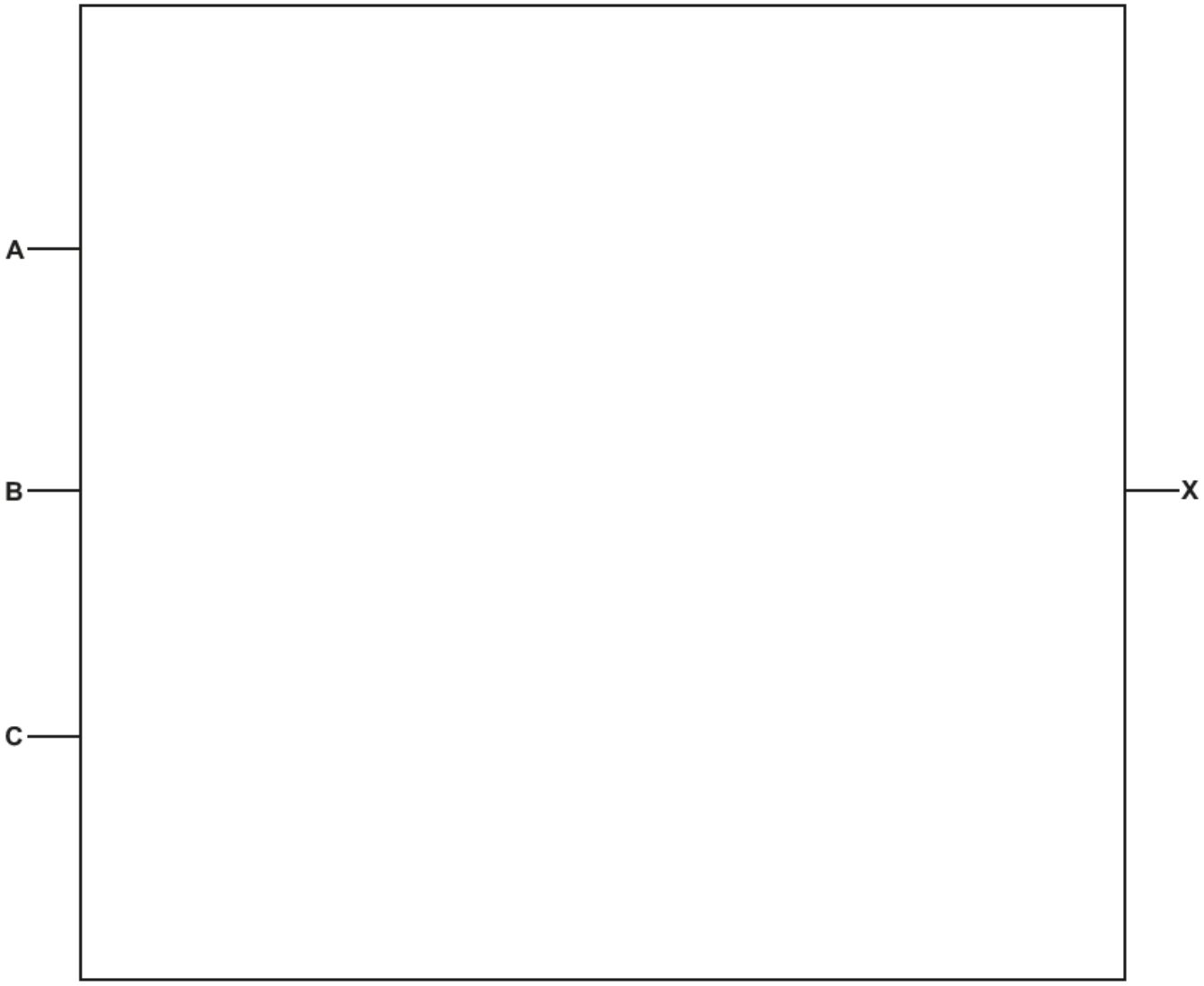
[2]

5 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]

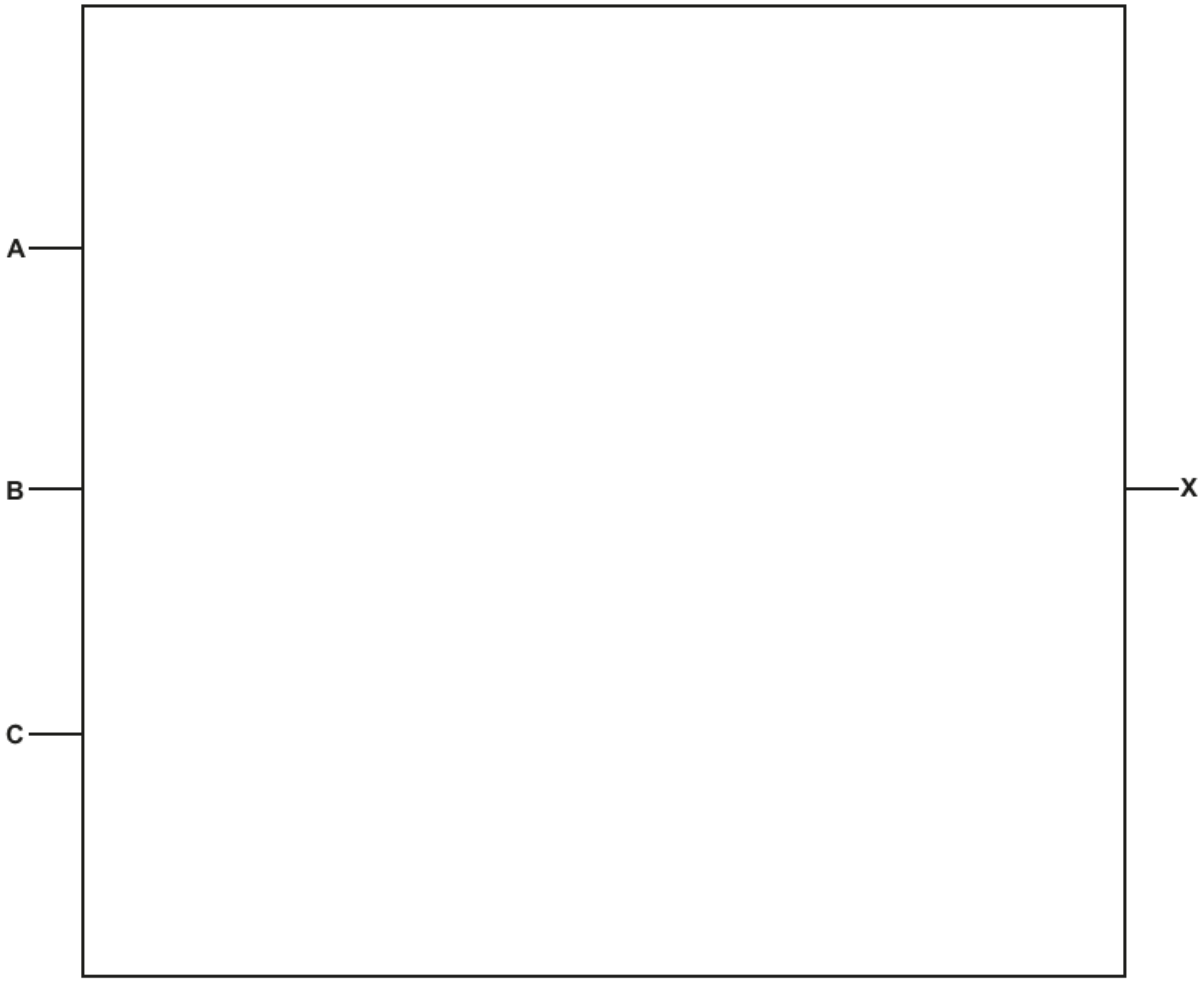
10 Boolean Logic
QUESTIONS

8 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		

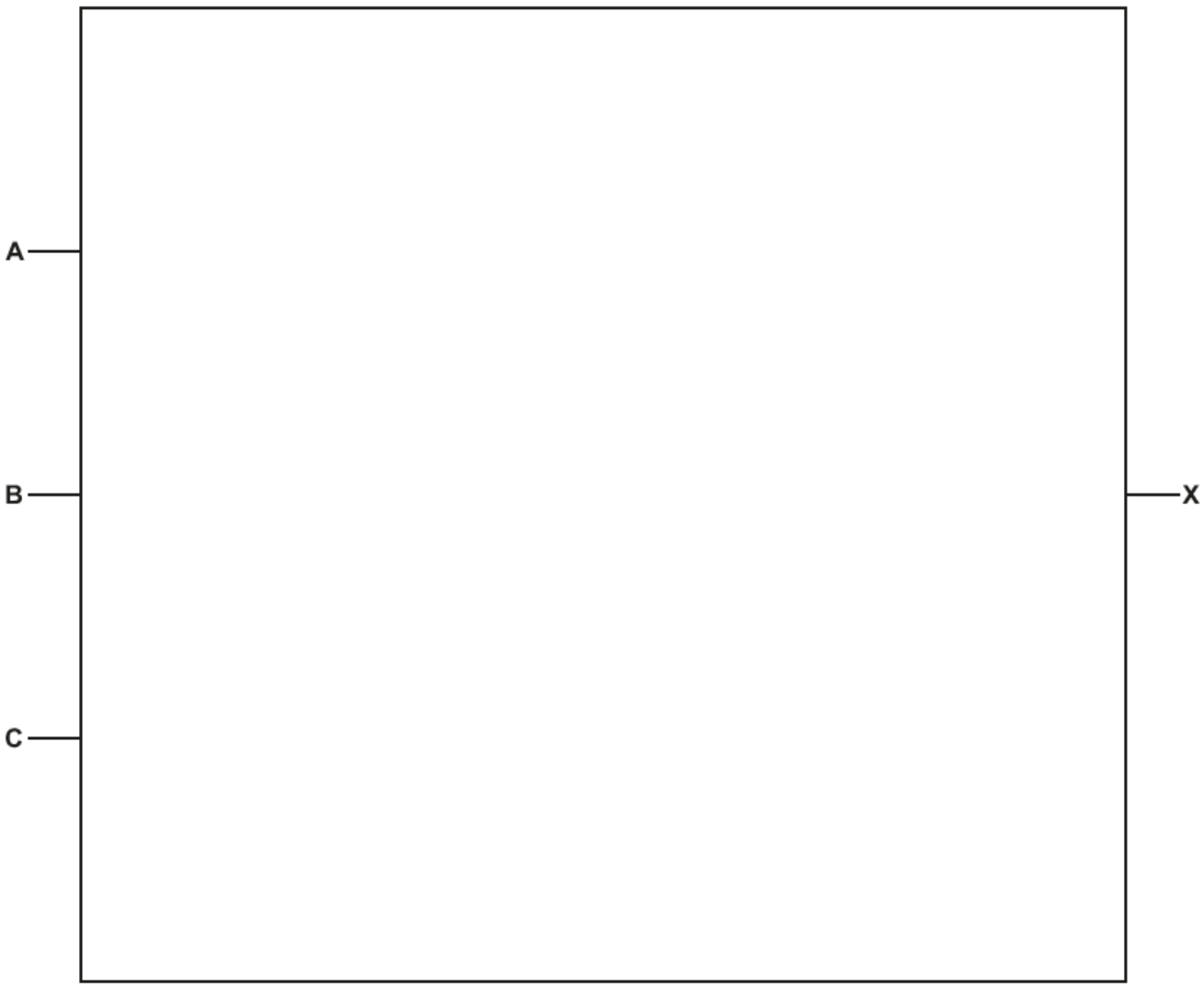
[4]

5 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]

3 **(a)** Tick (✓) to show which logic gates will give an output of 1 for the given inputs A and B.

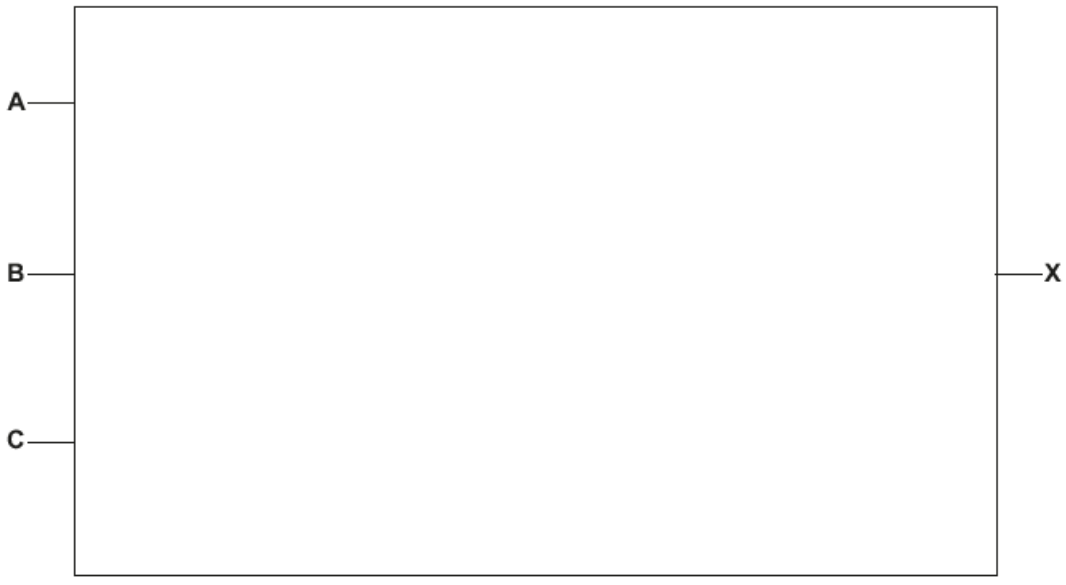
Inputs	AND	OR	NAND	NOR	XOR
A = 1 B = 1					
A = 0 B = 0					
A = 1 B = 0					

[3]

(b) Draw the logic circuit for the given logic statement:

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

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



[4]

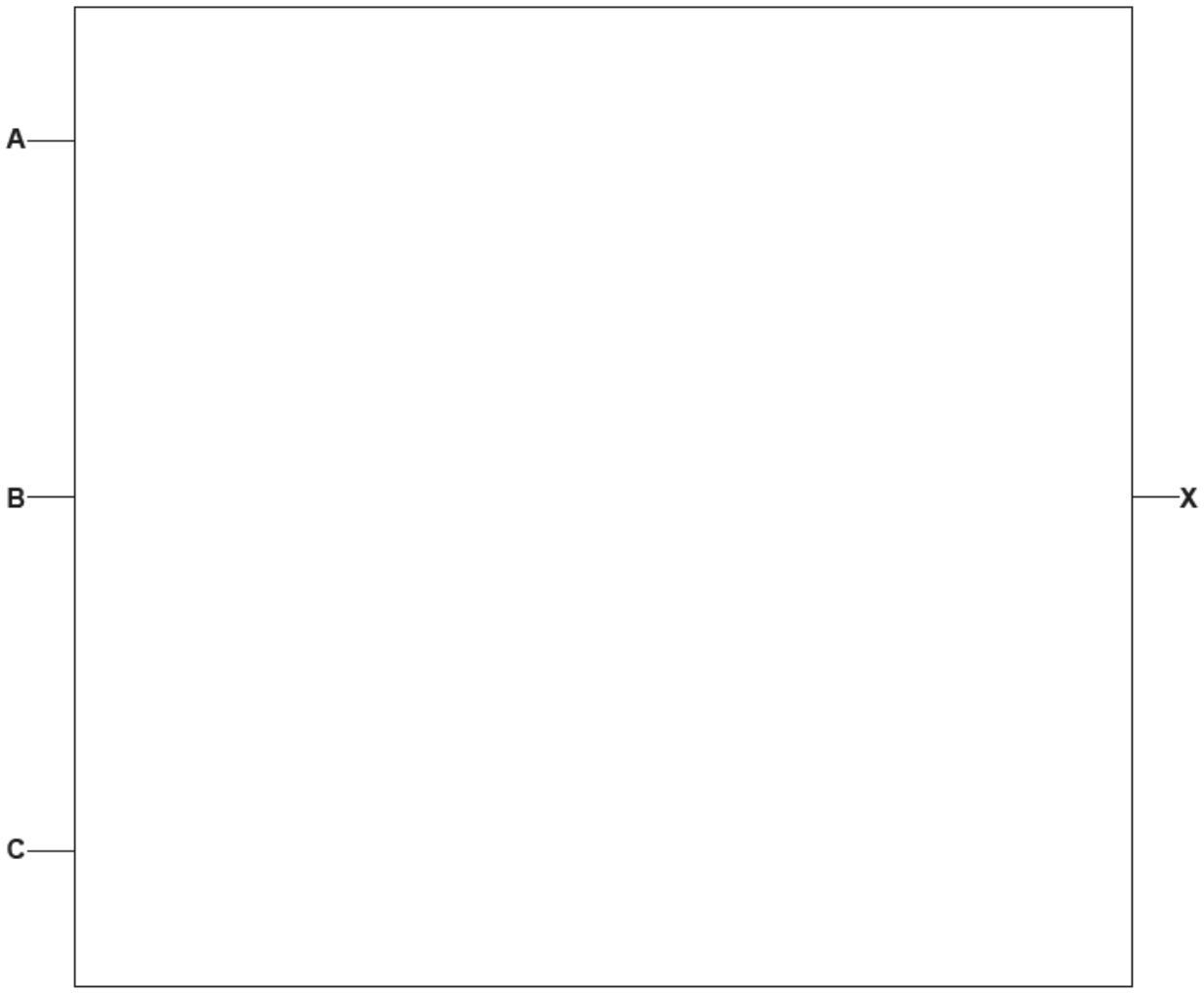
10 Boolean Logic
QUESTIONS

10 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]

10 Boolean Logic
QUESTIONS

(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		

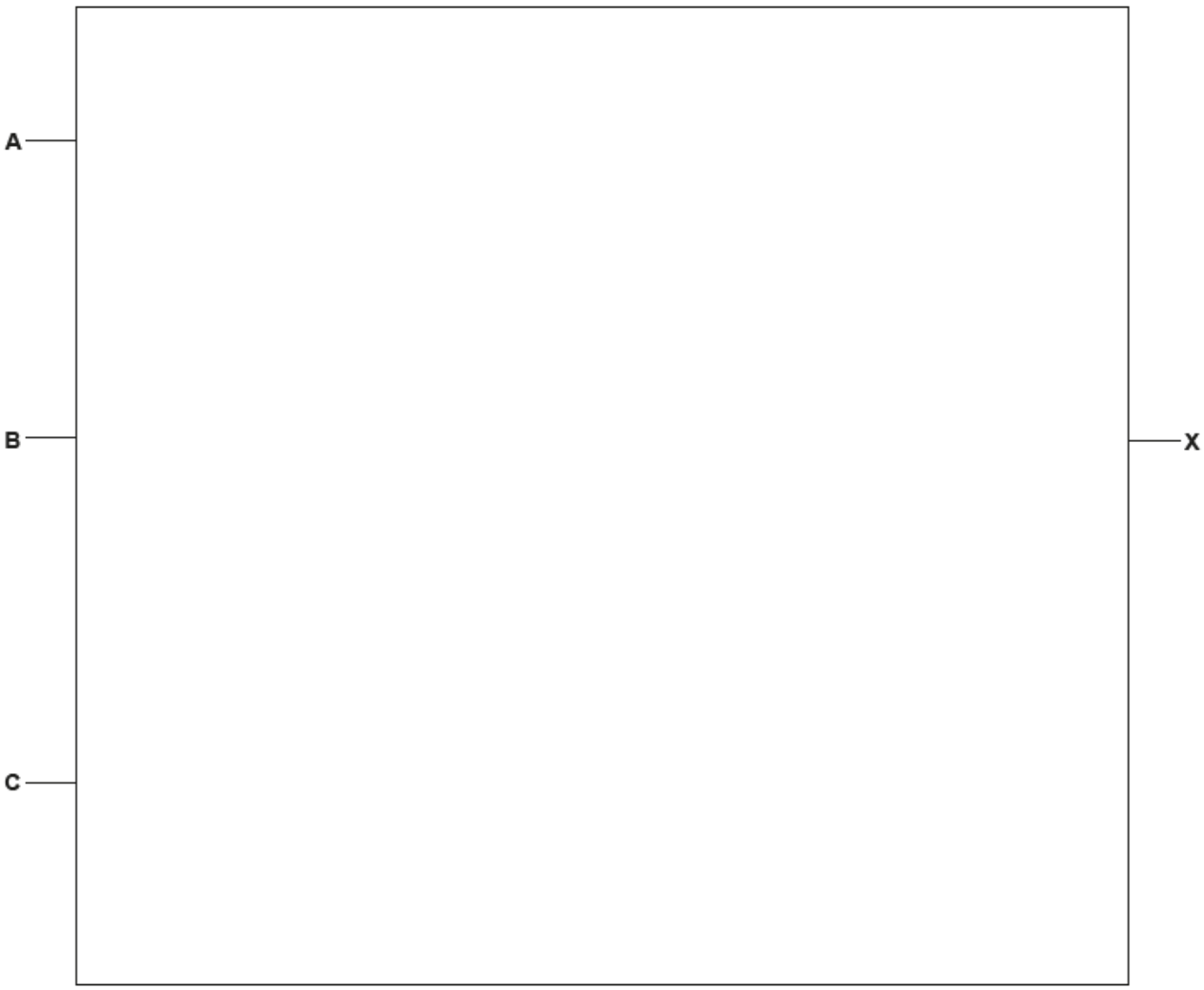
[4]

11 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]

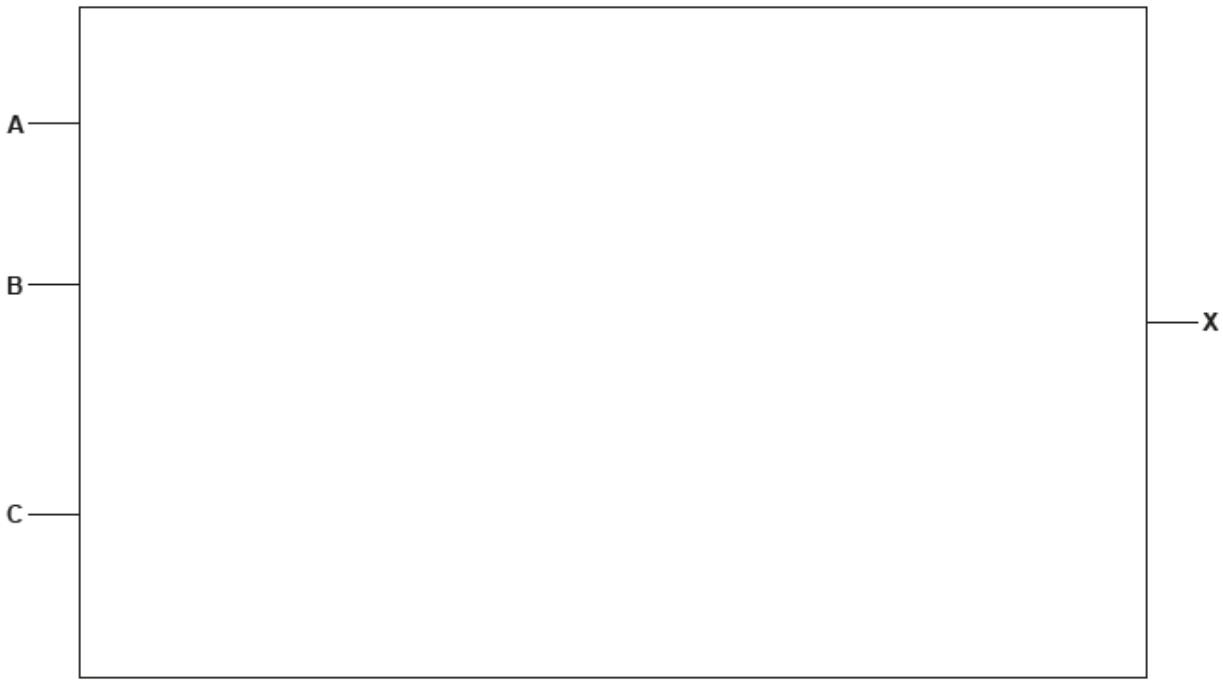
10 Boolean Logic
QUESTIONS

8 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]

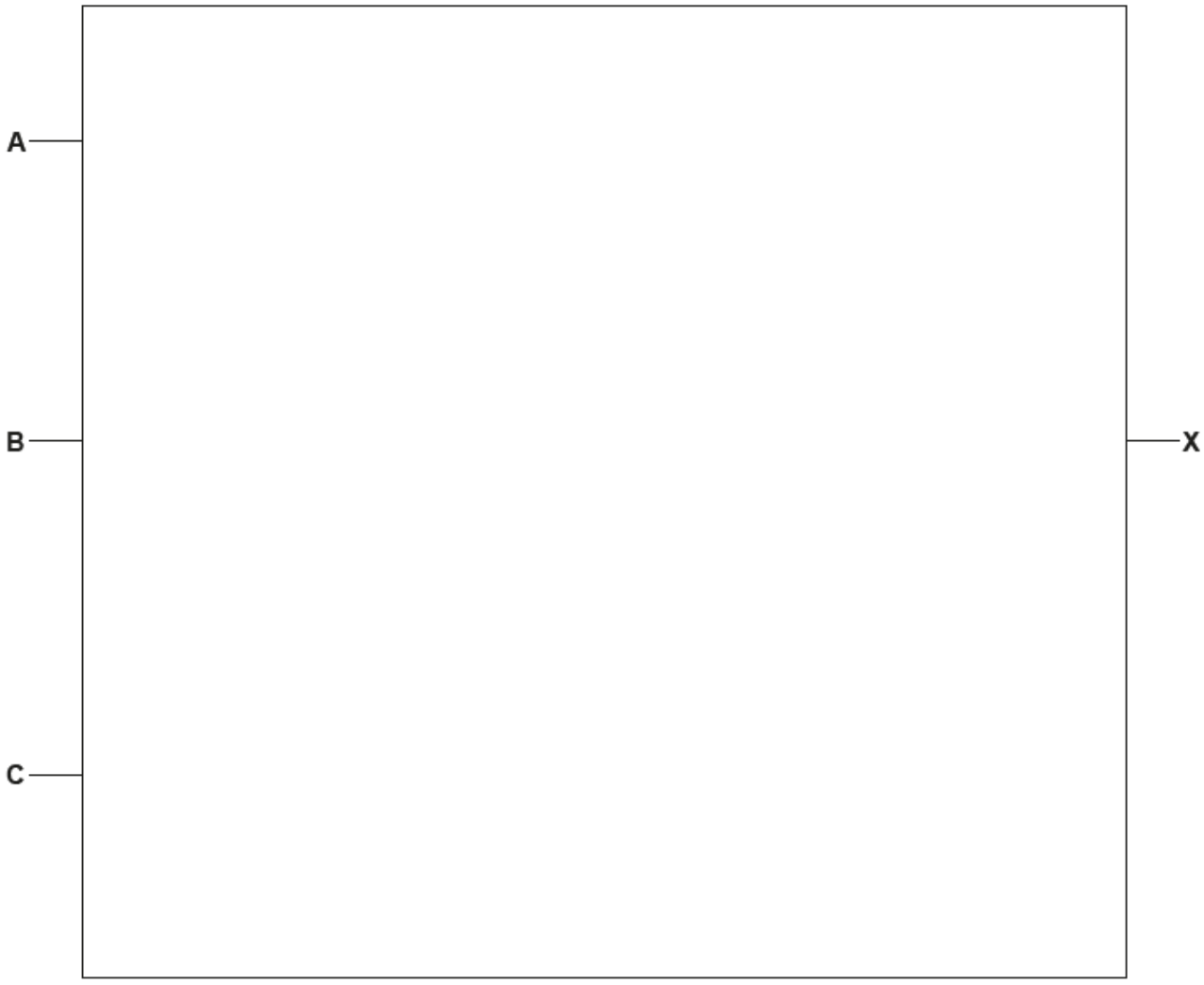
10 Boolean Logic
QUESTIONS

6 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]

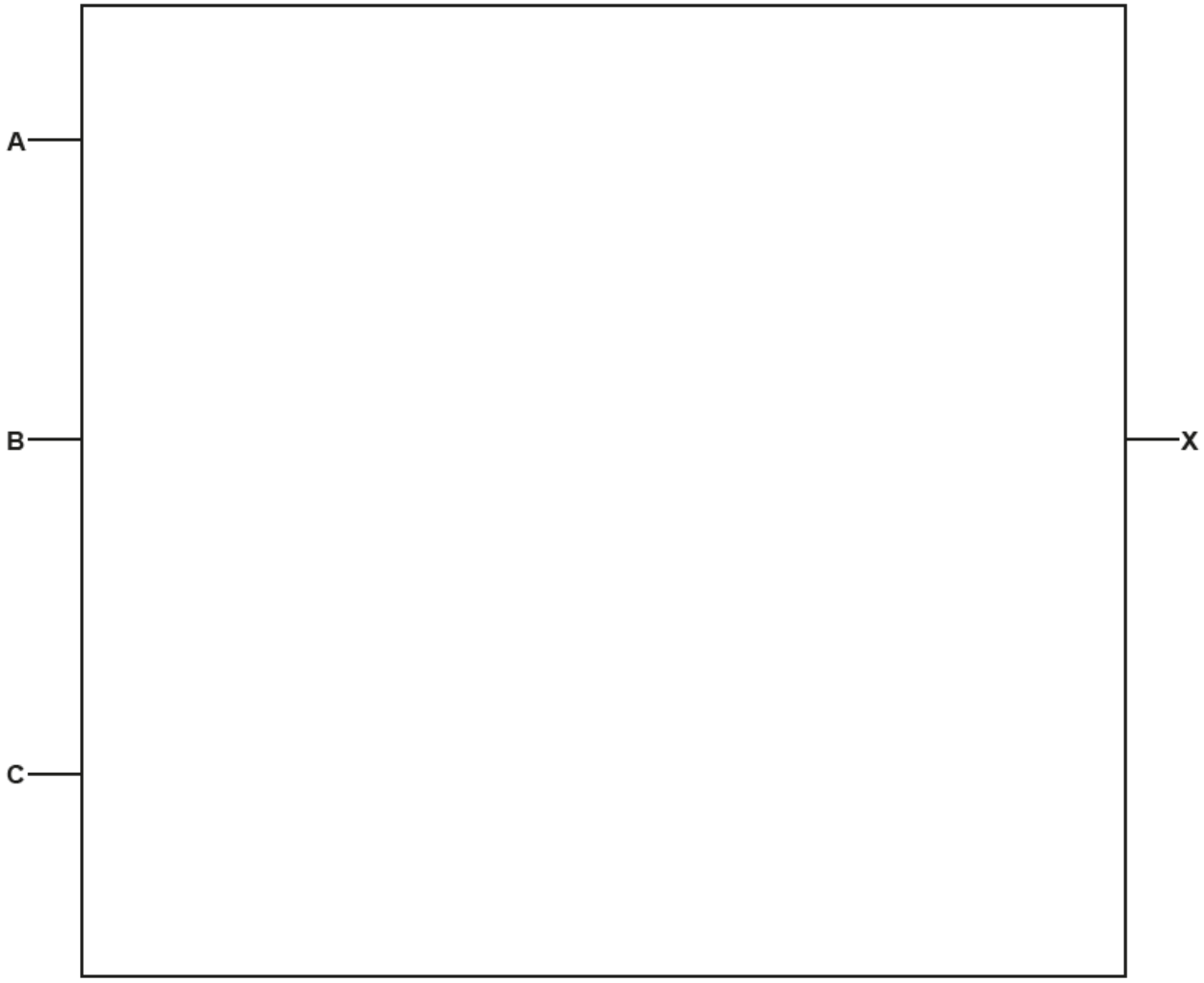
10 Boolean Logic
QUESTIONS

3 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 .....

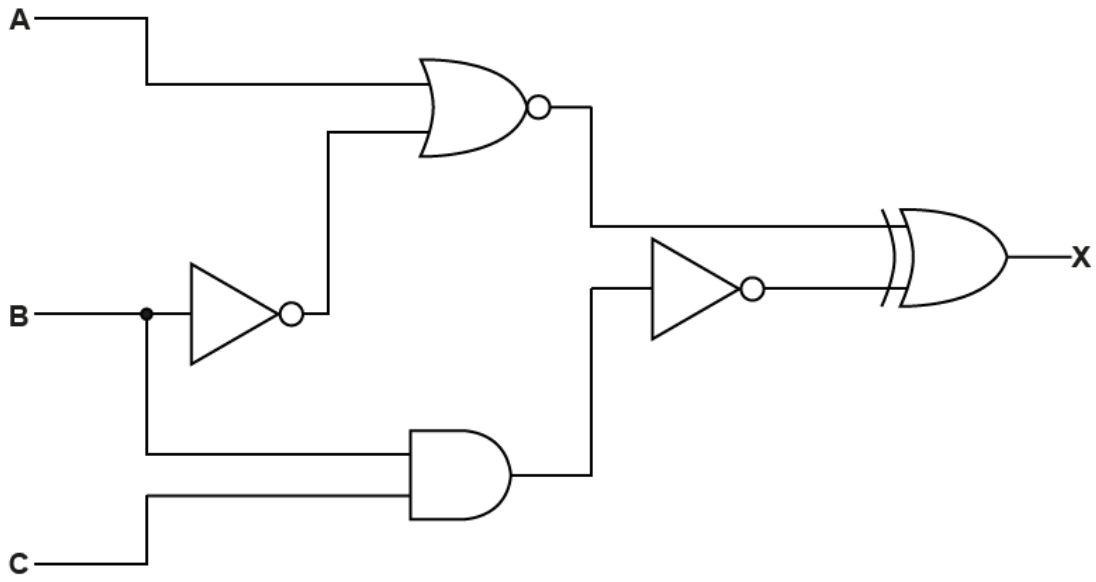
Row .....

Row .....

Row .....

[4]

8 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]

10 Boolean Logic
QUESTIONS

An aeroplane has a warning system that monitors the height of the aeroplane above the ground, whether the aeroplane is ascending or descending, and the speed of the aeroplane.

Input	Binary value	Condition
Height **(H)**	1	Height is less than 500 metres
	0	Height is greater than or equal to 500 metres
Ascending or Descending **(A)**	1	Aeroplane is ascending or in level flight
	0	Aeroplane is descending
Speed **(S)**	1	Speed is less than or equal to 470 knots
	0	Speed is greater than 470 knots

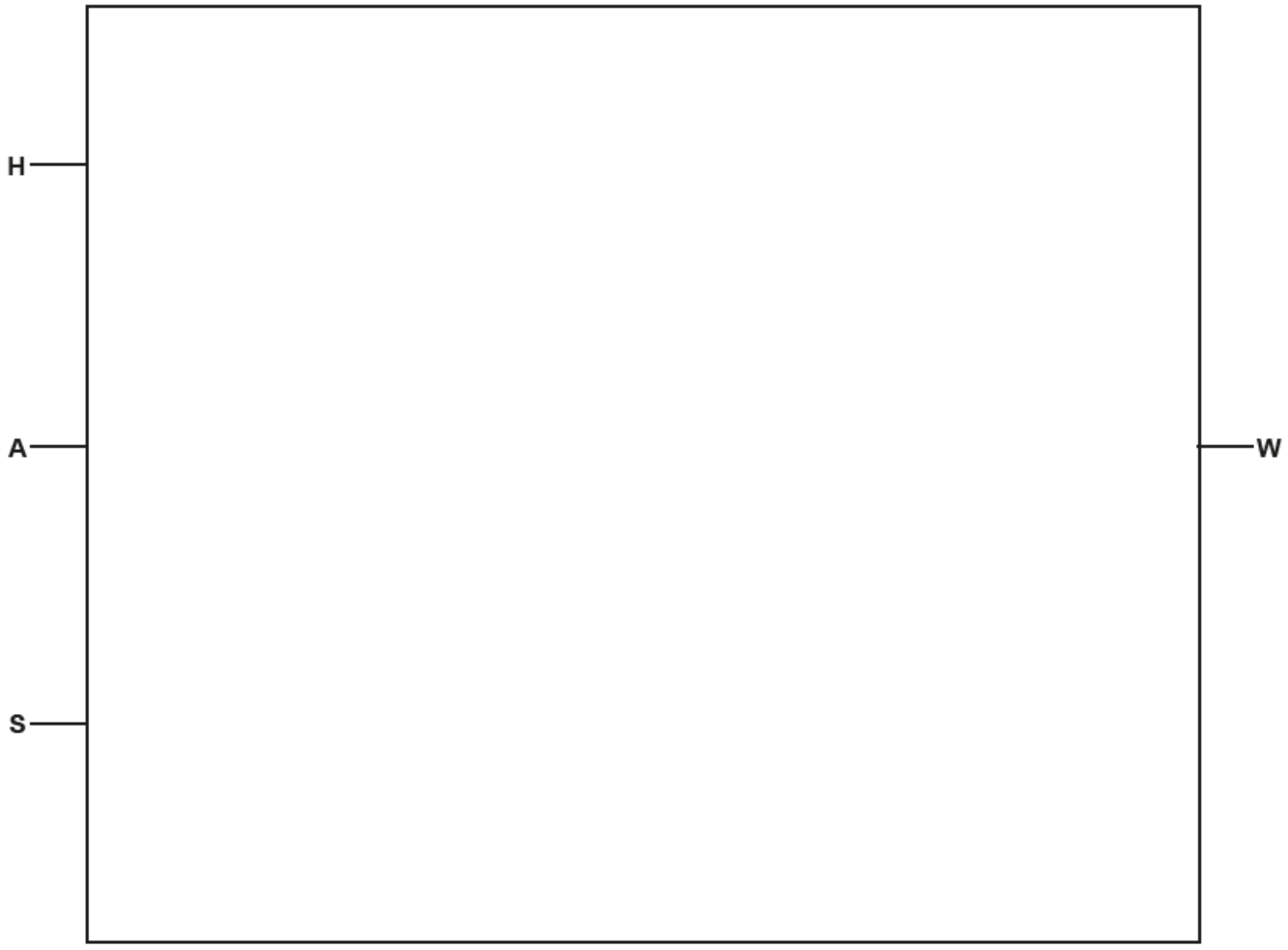
The warning system will produce an output of 1 that will sound an alarm (W) when either of these conditions apply:

Height is less than 500 metres and the aeroplane is descending

or

The aeroplane is descending and speed is greater than 470 knots

Draw a logic circuit to represent the warning system.



[5]