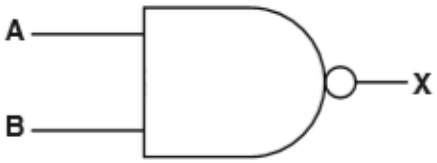
Past Papers May/June 2015 to 2018:

- **Logic Circuits,**
- **Boolean Algebra**
- **Flip Flops**
- **Kanugh Maps**

(9608/32/M/J/16)

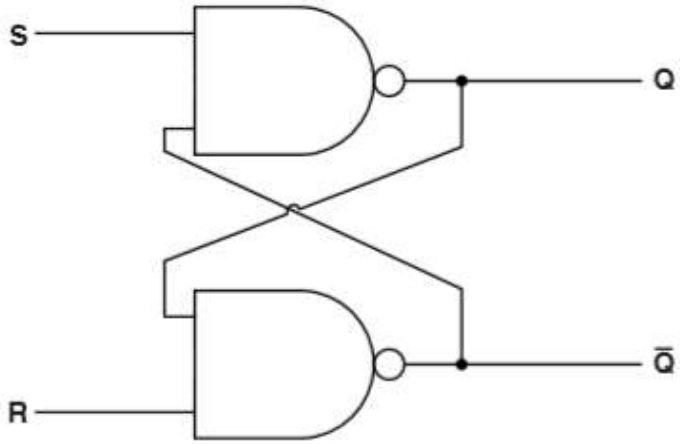
Q1/- (a) Complete the truth table for this NAND gate:



A	B	X
0	0	
0	1	
1	0	
1	1	

[1]

A SR flip-flop is constructed using two NAND gates.



(b) (i) Complete the truth table for the SR flip-flop.

	S	R	Q	$\bar{Q}$
Initially	1	0	0	1
R changed to 1	1	1		
S changed to 0	0	1		
S changed to 1	1	1		
S and R changed to 0	0	0		

[4]

(ii) One of the combinations in the truth table should not be allowed to occur.
State the values of S and R that should not be allowed. Justify your choice.

S = ... R = ...

.....

.....

.....

.....[3]

Another type of flip-flop is the JK flip-flop.

(c) (i) Give one extra input present in the JK flip-flop.

.....

.....[1]

(ii) Give one advantage of the JK flip-flop.

.....

.....[1]

(d) Describe the role of flip-flops in a computer.

.....

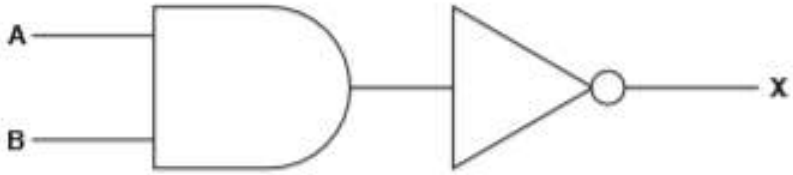
.....

.....

.....[2]

Q.2 **(9608/32/M/J/15)**

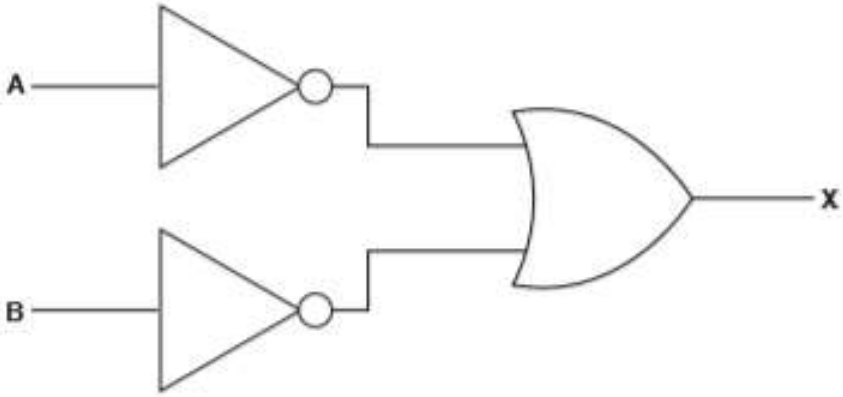
(a) (i) Complete the truth table for this logic circuit:



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

[1]

(ii) Complete the truth table for this logic circuit:



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

[1]

.....[1]

(b) A student decides to write an equation for X to represent the full behaviour of each logic circuit.

(i) Write the Boolean expression that will complete the required equation for X for each circuit:

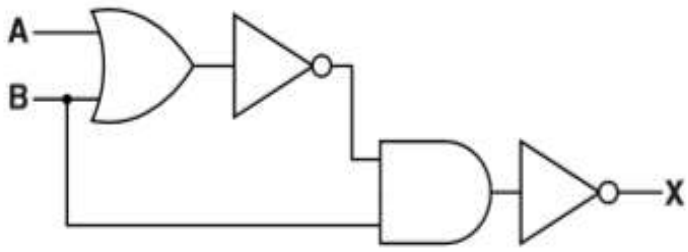
Circuit 1: X = ...

Circuit 2: X = ...[2]

(ii) Write the De Morgan's Law which is shown by your answers to part (a) and part

(b)(i).....[1]

(c) Write the Boolean algebraic expression corresponding to the following logic circuit:



.....[3]

(d) Using De Morgan's laws and Boolean algebra, simplify your answer to part (c). Show all your working.

.....

.....

.....

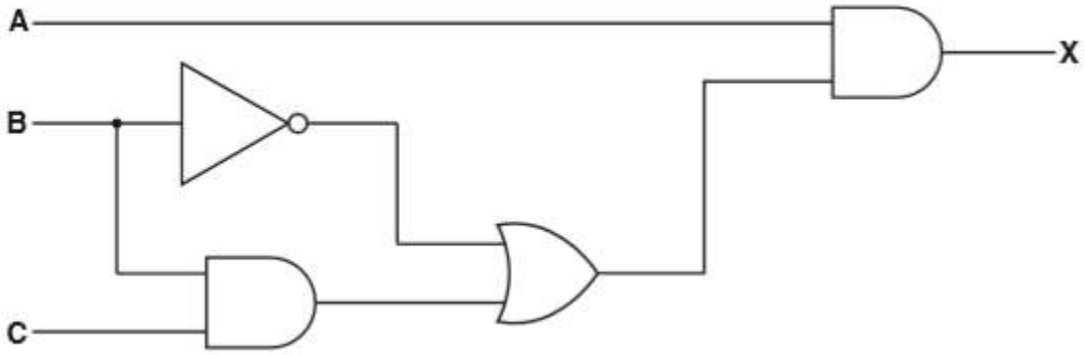
.....

.....

.....[3]

(9608/31/M/J/17)

3. Consider the following logic circuit, which contains a redundant logic gate.



(a) Write the Boolean algebraic expression corresponding to this logic circuit. X =

.....[3]

(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]

(c) (i) Complete the Karnaugh Map (K-map) for the truth table in part (b).

		AB 00	01	11	10
C	0				
	1				

[1]

The K-map can be used to simplify the expression in **part (a)**.

(ii) Draw loop(s) around appropriate groups to produce an optimal sum-of-products. [2]

(iii) Write a simplified sum-of-products expression, using your answer to part (ii).

X =
.....[2]

(d) One Boolean identity is:

$$A + \overline{A} \cdot B = A + B$$

Simplify the expression for X in part (a) to the expression for X in part (c)(iii). You should use the given identity.
.....

.....

.....

.....[2]

(9608/31/M/J/18)
4 (a) A Boolean expression produces the following truth table.

INPUT			OUTPUT
A	**B**	**C**	**X**
0	0	0	0
0	0	1	0
0	1	0	1
0	1	1	1
1	0	0	1
1	0	1	1
1	1	0	0
1	1	1	0

(i) Write the Boolean expression for the truth table as a sum-of-products.

X =
.....[2]

(ii) Complete the Karnaugh Map (K-map) for the truth table in part (a)(i).

C \ AB	00	01	11	10
0				
1				

[1]

The K-map can be used to simplify the function in part (a)(i).

(iii) Draw loop(s) around appropriate group(s) of 1s to produce an optimal sum-of-products for the table in part (a)(ii). [2]

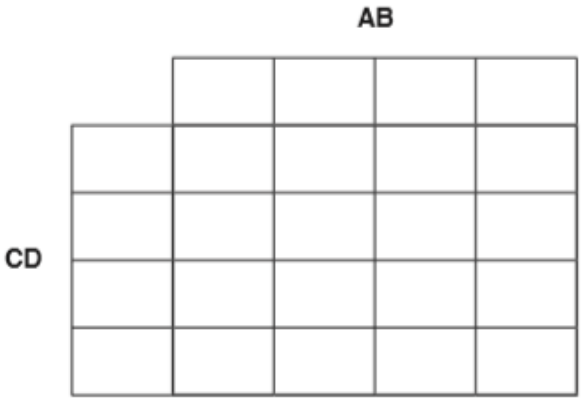
(iv) Write the simplified sum-of-products expression for your answer to part (a)(iii).

X =
..... [2]

(b) A logic circuit with four inputs produces the following truth table.

INPUT				OUTPUT
A	B	C	D	X
0	0	0	0	0
0	0	0	1	0
0	0	1	0	0
0	0	1	1	0
0	1	0	0	1
0	1	0	1	1
0	1	1	0	1
0	1	1	1	1
1	0	0	0	0
1	0	0	1	0
1	0	1	0	0
1	0	1	1	0
1	1	0	0	1
1	1	0	1	1
1	1	1	0	0
1	1	1	1	0

(i) Complete the K-map that corresponds to the truth table.



[4]

(ii) Draw loop(s) around appropriate group(s) of 1s to produce an optimal sum-of-products for the table in part **(b)(i).** [2]

(iii) Write the simplified sum-of-products expression for your answer to part (b)(ii).

X =
.....[2]

Answers:

1.

(a)

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

1

(b) (i)

S	R	Q	$\overline{Q}$
1	0	**0**	**1**
1	1	**0**	**1**
0	1	**1**	**0**
1	1	**1**	**0**
0	0	**1**	**1**

1
1
1
1

(ii) S = 0 R = 0 — **1**

Produces Q = 1 , $\overline{Q}$ =1 // Q and $\overline{Q}$ have same value — **1**
But Q and $\overline{Q}$ should be complements of each other — **1**
Becomes unstable — **1**

Max 3

(c) (i) Clock (pulse) — **1**

(ii)
All four possibilities are valid — **1**
The 1-1 combination changes output to logical complement — **1**
Unstable state avoided — **1**
Invalid state cannot occur // the flip-flop is stable — **1**

Max 1

(d) Memory // data storage — **1**
Stores a single bit — **1**

2.

(a) (i)

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

1

(ii)

Circuit 2		
A	B	X
0	0	**1**
0	1	**1**
1	0	**1**
1	1	**0**

1

(b) (i)

- circuit 1: $\overline{A.B}$ — 1
- circuit 2: $\overline{A} + \overline{B}$ — 1

(ii) $\overline{A.B} \equiv \overline{A} + \overline{B}$ — 1

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

Mark as follows:

$\overline{(A+B)}$ — 1

$.B$ — 1

bar over whole expression — 1

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

$= \overline{\overline{(A+B)}} + \overline{B}$ — 1

$= (A+B) + \overline{B}$ — 1

$= A + (B + \overline{B})$ — 1

$= A + 1$ — 1

$= 1$ — 1

allow f.t. from **(c)** — [max 3]

Total: 11

<table>
<tr><th>Question</th><th>Answer</th><th>Marks</th></tr>
<tr><td>3(a)</td><td>X = A.($\bar{B}$ + (B . C))
B.C 1
$\bar{B}$ + B.C 1
A. 1</td><td>3</td></tr>
<tr><td>3(b)</td><td>
<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>0</td></tr>
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<tr><td>1</td><td>1</td><td>1</td><td></td><td>1</td></tr>
</table>
1 mark first four entries, 1 mark for the last four entries</td><td>2</td></tr>
<tr><td>3(c)(i)</td><td>
<table>
<tr><th></th><th></th><th colspan="4">AB</th></tr>
<tr><th></th><th></th><th>00</th><th>01</th><th>11</th><th>10</th></tr>
<tr><td rowspan="2">C</td><td>0</td><td>0</td><td>0</td><td>0</td><td>1</td></tr>
<tr><td>1</td><td>0</td><td>0</td><td>1</td><td>1</td></tr>
</table>
</td><td>1</td></tr>
<tr><td>3(c)(ii)</td><td>
<table>
<tr><th></th><th></th><th colspan="4">AB</th></tr>
<tr><th></th><th></th><th>00</th><th>01</th><th>11</th><th>10</th></tr>
<tr><td rowspan="2">C</td><td>0</td><td>0</td><td>0</td><td>0</td><td>1</td></tr>
<tr><td>1</td><td>0</td><td>0</td><td>1</td><td>1</td></tr>
</table>
</td><td>2</td></tr>
<tr><td>3(c)(iii)</td><td>X = A.$\bar{B}$ + A.C
1 1</td><td>2</td></tr>
<tr><td>3(d)</td><td>X = A.($\bar{B}$ + (B . C))
X = A.($\bar{B}$ + C) 1
X = A.$\bar{B}$ + A.C 1 (dependent mark – must be correct outcome from previous line)</td><td>2</td></tr>
</table>

Question	Answer	Marks
4(a)(i)	**2** marks all products correct, **1** mark 2 or 3 products correct $X = \bar{A}.B.\bar{C} + \bar{A}.B.C + A.\bar{B}.\bar{C} + A.\bar{B}.C$	**2**
4(a)(ii)	**1** mark for all correct bits AB: 00, 01, 11, 10 C = 0: 0, 1, 0, 1 C = 1: 0, 1, 0, 1	**1**
4(a)(iii)	**1** mark for each correct loop AB: 00, 01, 11, 10 C = 0: 0, 1, 0, 1 C = 1: 0, 1, 0, 1	**2**
4(a)(iv)	**1** mark per bullet – allow follow through from **4(a)(iii)** • $\bar{A}.B$ • $+A.\bar{B}$ $X = \bar{A}.B + A.\bar{B}$	**2**
4(b)(i)	**1** mark per bullet max **2** • Correct column headings and row headings – values only • Correct column headings and row headings – order 1 mark for 2 correct rows/columns, 2 marks for 4 correct rows/columns (based on headings) max **2** AB: 00, 01, 11, 10 CD = 00: 0, 1, 1, 0 CD = 01: 0, 1, 1, 0 CD = 11: 0, 1, 0, 0 CD = 10: 0, 1, 0, 0	**4**
4(b)(ii)	**1** mark for each correct loop AB: 00, 01, 11, 10 CD = 00: 0, 1, 1, 0 CD = 01: 0, 1, 1, 0 CD = 11: 0, 1, 0, 0 CD = 10: 0, 1, 0, 0	**2**

4(b)(iii)	**1** mark per bullet $\bar{A}.B$ $+B.\bar{C}$ $X = \bar{A}.B + B.\bar{C}$	**2**