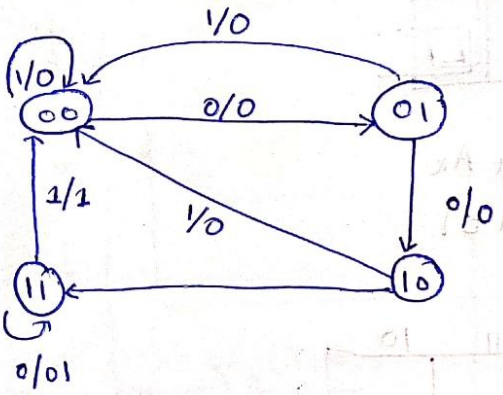
**Question Number 1** **[3 + 2 + 3 + 2 = 10 Marks]**

Design a sequential circuit by using D Flip Flop to detect the sequence of three or more 0's in an input sequence of bits. The output of the circuit should be 1 when three or more 0's appears at the input, otherwise the output should be 0. You can complete your design by constructing

- State Diagram
- State Table
- Flip Flop Input Equations
- Circuit Diagram

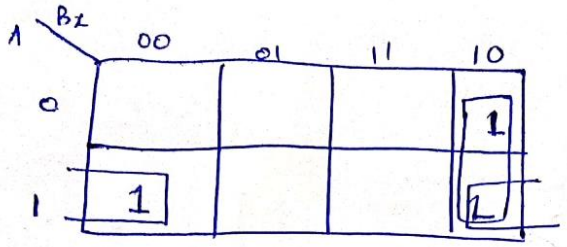
- **State Diagram:-**



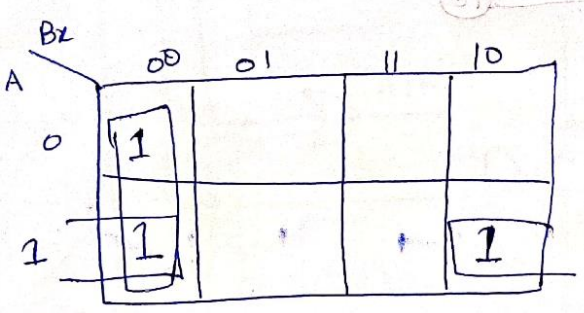

- **State Table:-**

| Present state | | Input | Next state | | Output |
|---|---|---|---|---|---|
| A | B | x | A(t+1) | B(t+1) | y |
| 0 | 0 | 0 | 0 | 1 | 0 |
| 0 | 0 | 1 | 0 | 0 | 0 |
| 0 | 1 | 0 | 1 | 0 | 0 |
| 0 | 1 | 1 | 0 | 0 | 0 |
| 1 | 0 | 0 | 1 | 1 | 0 |
| 1 | 0 | 1 | 0 | 0 | 0 |
| 1 | 1 | 0 | 1 | 1 | 1 |
| 1 | 1 | 1 | 0 | 0 | 1 |

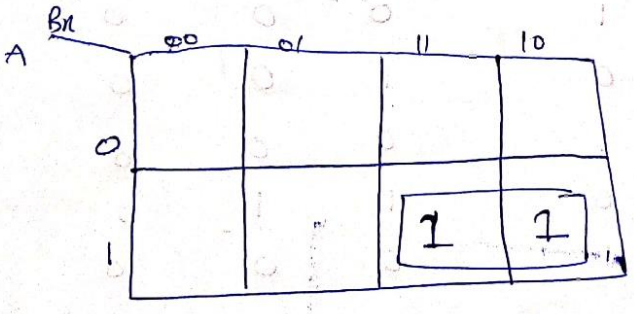
- **Flip - Flop Input equations :-**




$$A(t+1) = Bx' + Ax'$$
$$= x'(A + B)$$

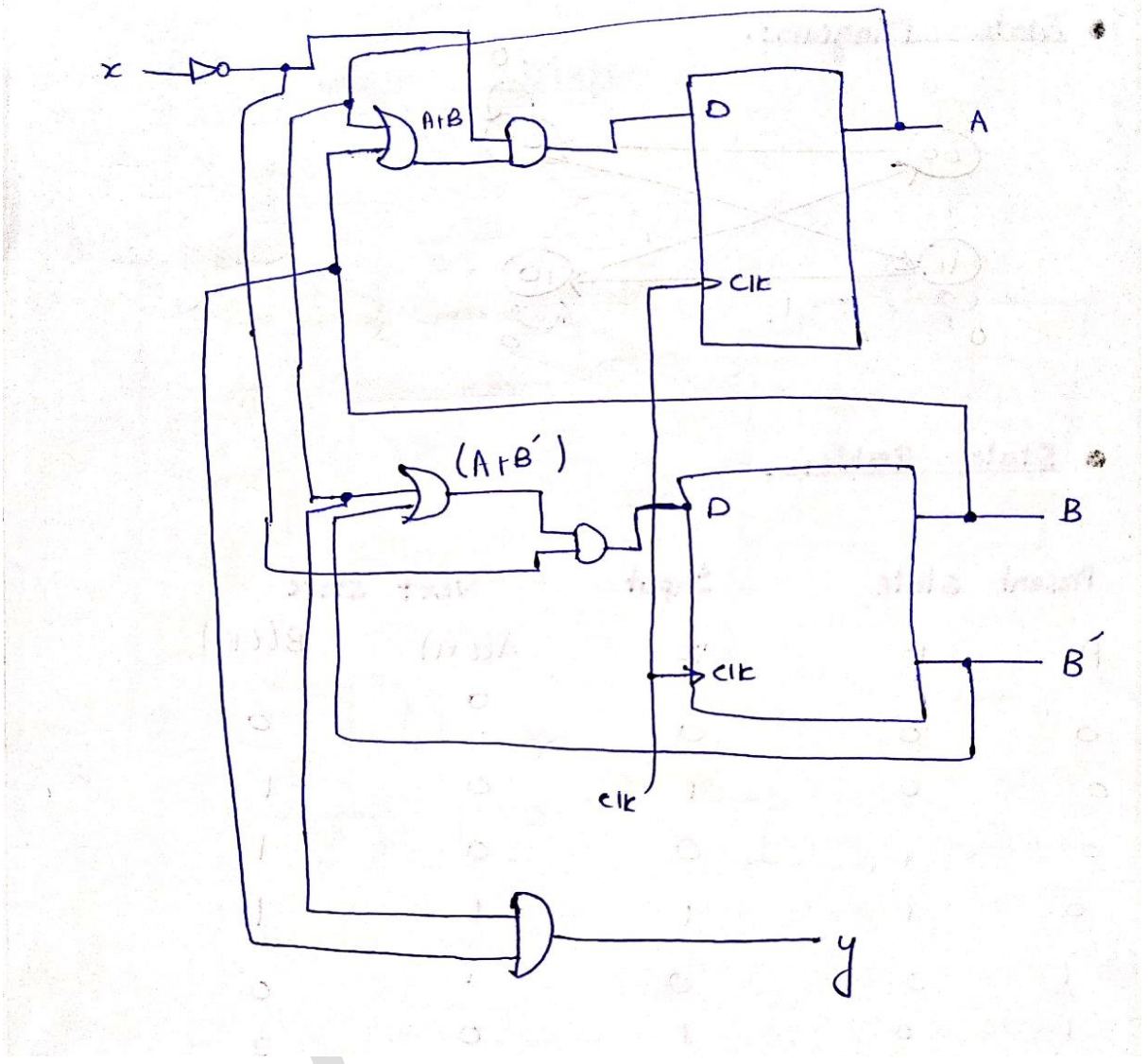



$$B(t+1) = Bx' + Ax'$$
$$= x'(A + B)$$




$$y = AB$$

- **Circuit Diagram:-**



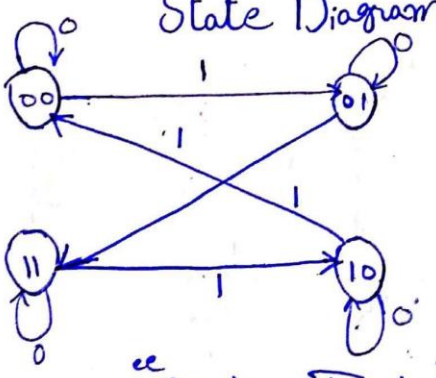
**Question Number 2** **[3 + 2 + 3 + 2 = 10 Marks]**

Design a sequential circuit with two D flip-flops A and B, and one input x. When x = 0, the state of the circuit remains the same. When x = 1, the circuit goes through the state transitions from 00 to 01, to 11, to 10, back to 00, and repeats. Complete your design by constructing

- State Diagram
- State Table
- Flip Flop Input Equations
- Circuit Diagram

Question no. 2

a) "State Diagram"

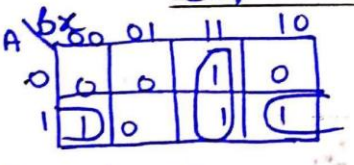



b) "State Table"

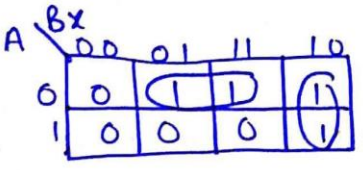
| Present State A | Present State B | Input x | Next State A | Next State B |
|---|---|---|---|---|
| 0 | 0 | 0 | 0 | 0 |
| 0 | 0 | 1 | 0 | 1 |
| 0 | 1 | 0 | 0 | 1 |
| 0 | 1 | 1 | 1 | 0 |
| 1 | 0 | 0 | 1 | 0 |
| 1 | 0 | 1 | 1 | 1 |
| 1 | 1 | 0 | 1 | 0 |
| 1 | 1 | 1 | 0 | 0 |

"Equations"

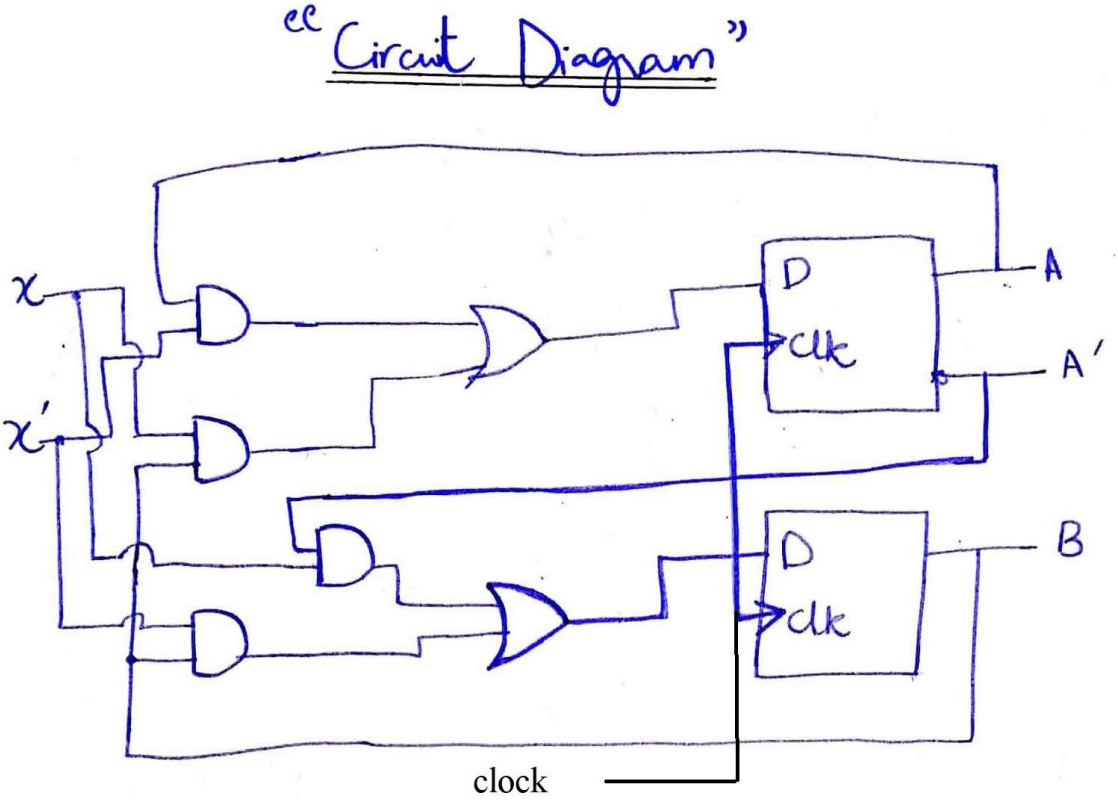
c)




$D_A = Ax + Bx$




$D_B = A'x + Bx'$



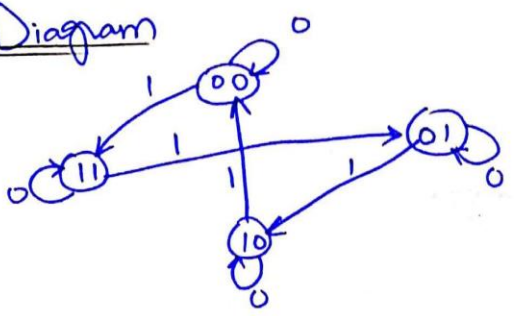

**Question Number 3** **[3 + 2 + 2 + 3 + 2 = 12 Marks]**

Design a sequential circuit with two JK flip-flops A and B, and one input x. When x = 0, the state of the circuit remains the same. When x =1, the circuit goes through the state transitions from 00 to 11, to 01, to 10, back to 00, and repeats. Complete your design by finding:

- State Diagram
- State Table
- Flip Flop Inputs
- Flip Flop Input Equation
- Circuit Diagram

## Question no. 3:

## State Diagram




## State Table and FF inputs.

| Present State | | Input | Next State | | FF inputs | | | |
|---|---|---|---|---|---|---|---|---|
| A | B | x | A | B | $J_A$ | $K_A$ | $J_B$ | $K_B$ |
| 0 | 0 | 0 | 0 | 0 | 0 | x | 0 | x |
| 0 | 0 | 1 | 0 | 1 | 1 | x | 1 | x |
| 0 | 1 | 0 | 0 | 1 | 0 | x | x | 0 |
| 0 | 1 | 1 | 1 | 0 | 1 | x | x | 1 |
| 0 | 1 | 0 | 1 | 0 | x | 0 | 0 | x |
| 1 | 0 | 1 | 0 | 0 | x | 1 | 0 | x |
| 1 | 0 | 0 | 1 | 1 | x | 0 | x | 0 |
| 1 | 1 | 1 | 0 | 1 | x | 1 | x | 0 |

## Flip flop input equations.

$J_A$

| A \ Bx | 00 | 01 | 11 | 10 |
|---|---|---|---|---|
| 0 | 0 | 1 | 1 | 0 |
| 1 | x | x | x | x |

$J_A = x$

$J_B$

| A \ Bx | 00 | 01 | 11 | 10 |
|---|---|---|---|---|
| 0 | 0 | 1 | x | x |
| 1 | 0 | 0 | x | x |

$J_B = A'x$

$K_A$

| A \ Bx | 00 | 01 | 11 | 10 |
|---|---|---|---|---|
| 0 | x | x | x | x |
| 1 | 0 | 1 | 1 | 0 |

$K_A = x$

$K_B$

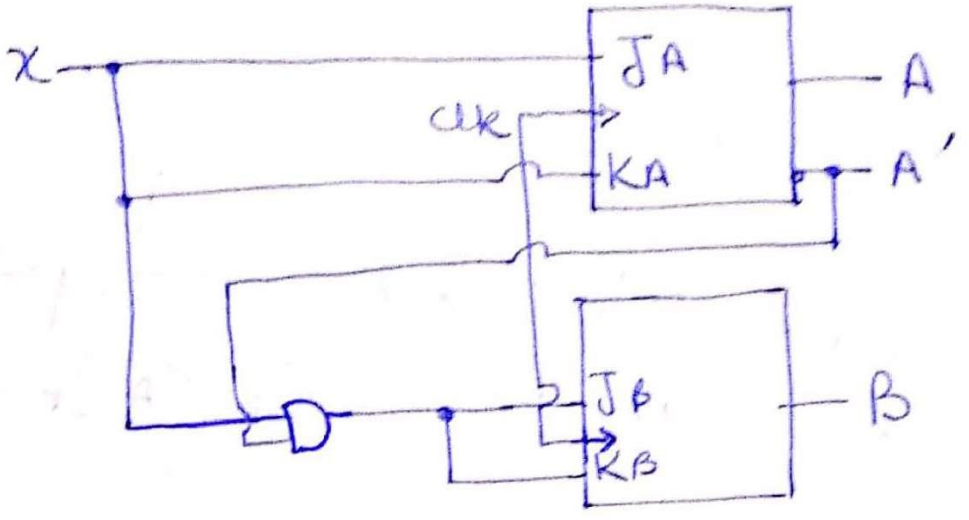
| A \ Bx | 00 | 01 | 11 | 10 |
|---|---|---|---|---|
| 0 | x | x | 1 | 0 |
| 1 | x | x | 0 | 0 |

$K_B = A'x$

$K_A = x$

$K_B = A'x$

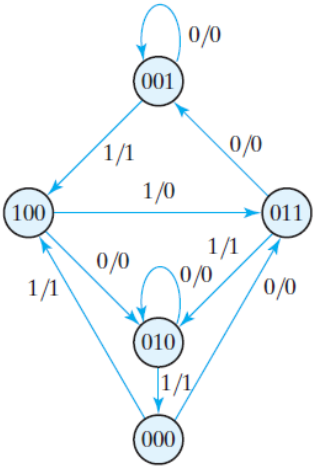
Logic Diagram




**Question Number 4** **[10 + 12 + 12 = 34 Marks]**

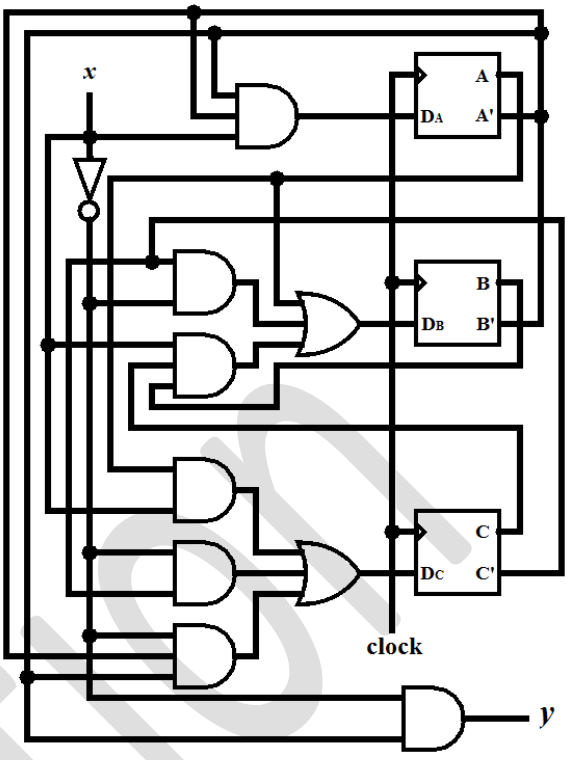
A sequential circuit has three flip-flops A, B, C ; one input x; and one output y. The state diagram is shown in figure below. The circuit is to be designed by treating the unused states as don't-care conditions.

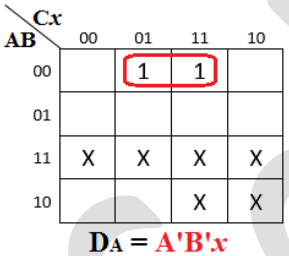
i. Use D Flip Flops for design
ii. Use JK Flip Flops for desing
iii. Use T Flip Flops for design



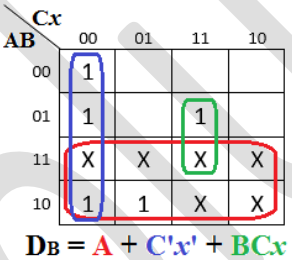
**i. With D Flip Flop**

| Present State | | | Input | Next State | | | Output |
|---|---|---|---|---|---|---|---|
| A | B | C | *x* | A | B | C | *y* |
| 0 | 0 | 0 | 0 | 0 | 1 | 1 | 0 |
| 0 | 0 | 0 | 1 | 1 | 0 | 0 | 1 |
| 0 | 0 | 1 | 0 | 0 | 0 | 1 | 0 |
| 0 | 0 | 1 | 1 | 1 | 0 | 0 | 1 |
| 0 | 1 | 0 | 0 | 0 | 1 | 0 | 0 |
| 0 | 1 | 0 | 1 | 0 | 0 | 0 | 1 |
| 0 | 1 | 1 | 0 | 0 | 0 | 1 | 0 |
| 0 | 1 | 1 | 1 | 0 | 1 | 0 | 1 |
| 1 | 0 | 0 | 0 | 0 | 1 | 0 | 0 |
| 1 | 0 | 0 | 1 | 0 | 1 | 1 | 0 |
| 1 | 0 | 1 | 0 | X | X | X | X |
| 1 | 0 | 1 | 1 | X | X | X | X |
| 1 | 1 | 0 | 0 | X | X | X | X |
| 1 | 1 | 0 | 1 | X | X | X | X |
| 1 | 1 | 1 | 0 | X | X | X | X |
| 1 | 1 | 1 | 1 | X | X | X | X |

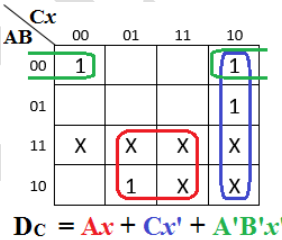


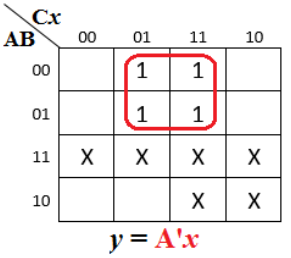

$D_A = A'B'x$




$D_B = A + C'x' + BCx$




$D_C = Ax + Cx' + A'B'x'$




$y = A'x$

**ii. With JK Flip Flop**

| Present State | | | Input | Next State | | | Output | Flip Flop Inputs | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| A | B | C | *x* | A | B | C | *y* | $J_A$ | $K_A$ | $J_B$ | $K_B$ | $J_C$ | $K_C$ |
| 0 | 0 | 0 | 0 | 0 | 1 | 1 | 0 | 0 | X | 1 | X | 1 | X |
| 0 | 0 | 0 | 1 | 1 | 0 | 0 | 1 | 1 | X | 0 | X | 0 | X |
| 0 | 0 | 1 | 0 | 0 | 0 | 1 | 0 | 0 | X | 0 | X | X | 0 |
| 0 | 0 | 1 | 1 | 1 | 0 | 0 | 1 | 1 | X | 0 | X | X | 1 |
| 0 | 1 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | X | X | 0 | 0 | X |
| 0 | 1 | 0 | 1 | 0 | 0 | 0 | 1 | 0 | X | X | 1 | 0 | X |
| 0 | 1 | 1 | 0 | 0 | 0 | 1 | 0 | 0 | X | X | 1 | X | 0 |
| 0 | 1 | 1 | 1 | 0 | 1 | 0 | 1 | 0 | X | X | 0 | X | 1 |
| 1 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | X | 1 | 1 | X | 0 | X |
| 1 | 0 | 0 | 1 | 0 | 1 | 1 | 0 | X | 1 | 1 | X | 1 | X |
| 1 | 0 | 1 | 0 | X | X | X | X | X | X | X | X | X | X |
| 1 | 0 | 1 | 1 | X | X | X | X | X | X | X | X | X | X |
| 1 | 1 | 0 | 0 | X | X | X | X | X | X | X | X | X | X |
| 1 | 1 | 0 | 1 | X | X | X | X | X | X | X | X | X | X |
| 1 | 1 | 1 | 0 | X | X | X | X | X | X | X | X | X | X |
| 1 | 1 | 1 | 1 | X | X | X | X | X | X | X | X | X | X |

By using k-maps the equations for $J_A$, $K_A$, $J_B$, $K_B$, $J_C$, $K_C$ and *y* can be found.

$J_A = B'x$ $\quad K_A = 1$

$J_B = A + C'x'$ $\quad K_B = C'x + Cx'$

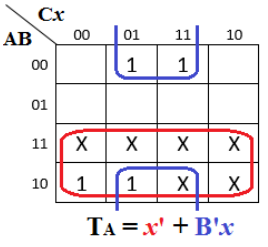
$J_C = Ax + A'B'x'$ $\quad K_C = x$

$y = A'x$

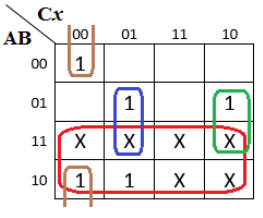
The above equations can be used to draw the circuit diagram

**iii. With T Flip Flops**

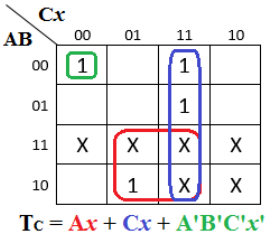
| Present State | | | Input | Next State | | | Output | Flip Flop Inputs | | |
|---|---|---|---|---|---|---|---|---|---|---|
| A | B | C | *x* | A | B | C | *y* | $T_A$ | $T_B$ | $T_C$ |
| 0 | 0 | 0 | 0 | 0 | 1 | 1 | 0 | 0 | 1 | 1 |
| 0 | 0 | 0 | 1 | 1 | 0 | 0 | 1 | 1 | 0 | 0 |
| 0 | 0 | 1 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 |
| 0 | 0 | 1 | 1 | 1 | 0 | 0 | 1 | 1 | 0 | 1 |
| 0 | 1 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 |
| 0 | 1 | 0 | 1 | 0 | 0 | 0 | 1 | 0 | 1 | 0 |
| 0 | 1 | 1 | 0 | 0 | 0 | 1 | 0 | 0 | 1 | 0 |
| 0 | 1 | 1 | 1 | 0 | 1 | 0 | 1 | 0 | 0 | 1 |
| 1 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 1 | 1 | 0 |
| 1 | 0 | 0 | 1 | 0 | 1 | 1 | 0 | 1 | 1 | 1 |
| 1 | 0 | 1 | 0 | X | X | X | X | X | X | X |
| 1 | 0 | 1 | 1 | X | X | X | X | X | X | X |
| 1 | 1 | 0 | 0 | X | X | X | X | X | X | X |
| 1 | 1 | 0 | 1 | X | X | X | X | X | X | X |
| 1 | 1 | 1 | 0 | X | X | X | X | X | X | X |
| 1 | 1 | 1 | 1 | X | X | X | X | X | X | X |




$T_A = x' + B'x$




$T_B = A + BC'x + BCx' + B'C'x'$




$T_C = Ax + Cx + A'B'C'x'$

The above equations can be used to draw circuit diagram.

**Question Number 5** **[3 + 8 + 3 = 14 Marks]**

For the following state table:

| Present State | Next State | | Output | |
|---|---|---|---|---|
| | $x = 0$ | $x = 1$ | $x = 0$ | $x = 1$ |
| $a$ | $f$ | $b$ | 0 | 0 |
| $b$ | $d$ | $c$ | 0 | 0 |
| $c$ | $f$ | $e$ | 0 | 0 |
| $d$ | $g$ | $a$ | 1 | 0 |
| $e$ | $d$ | $c$ | 0 | 0 |
| $f$ | $f$ | $b$ | 1 | 1 |
| $g$ | $g$ | $h$ | 0 | 1 |
| $h$ | $g$ | $a$ | 1 | 0 |

i. Draw the corresponding state diagram.
ii. Tabulate the reduced state table.
iii. Draw the state diagram corresponding to the reduced state table

| Present State | Next State | | Output | |
|---|---|---|---|---|
| | $x = 0$ | $x = 1$ | $x = 0$ | $x = 1$ |
| a | f | b | 0 | 0 |
| b | d | c | 0 | 0 |
| c | f | e | 0 | 0 |
| d | g | a | 1 | 0 |
| e | d | c | 0 | 0 |
| f | f | b | 1 | 1 |
| g | g | h | 0 | 1 |
| h | g | a | 1 | 0 |

States b and e are equivalent, and d and h are also equivalent. So, removing e and h, and then replacing e and h with b and d respectively in remaining table we get.

| Present State | Next State | | Output | |
|---|---|---|---|---|
| | $x = 0$ | $x = 1$ | $x = 0$ | $x = 1$ |
| a | f | b | 0 | 0 |
| b | d | c | 0 | 0 |
| c | f | b | 0 | 0 |
| d | g | a | 1 | 0 |
| f | f | b | 1 | 1 |
| g | g | d | 0 | 1 |

States a and c are equivalent, removing c and replacing c with a in remaining table, we get.

| Present State | Next State | | Output | |
|---|---|---|---|---|
| | $x = 0$ | $x = 1$ | $x = 0$ | $x = 1$ |
| a | f | b | 0 | 0 |
| b | d | a | 0 | 0 |
| d | g | a | 1 | 0 |
| f | f | b | 1 | 1 |
| g | g | d | 0 | 1 |

There are no more equivalent states, so this is the reduced state table.

State diagrams can be drawn from the given and reduced state tables easily.