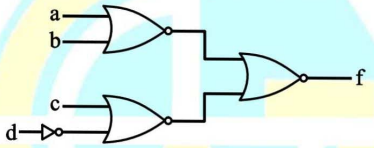
Digital Electronics

1. Logic Gate

Q.1 The Boolean function Y = AB + CD is to be realized using only 2-input NAND gates. The minimum number of gates required is _____.

Q.2 Which one of the following is the correct output (f) of the below circuit ?



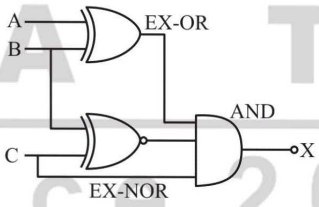
(A) $(a + b)(c + \bar{d})$ (B) $(\bar{a} + \bar{b})(c + \bar{d})$ (C) $(a + \bar{b})(c + \bar{d})$ (D) $(a + b)(\bar{a} + \bar{d})$

Q.3 The Boolean expression Y(A, B, C) = A + BC is to be realized using 2-input gates of only one type. What is the minimum number of gates required for the realization ? _____.

Q.4 The minimum number of 2-input NAND gates required to implement the Boolean function $Z = A\bar{B}C$, assuming that *A*, *B* and *C* are available is **[GATE 1998, IIT Delhi]**

(A) two (B) three (C) five (D) six

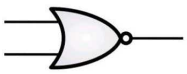
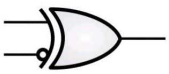
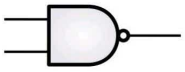
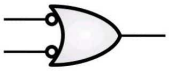
Q.5

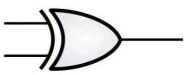


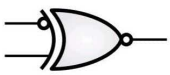
For the logic circuit shown in the above figure, what is the required input condition (A, B, C) to make output X = 1 ?

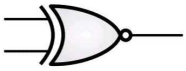
(A) 1, 0, 1 (B) 0, 0, 1 (C) 1, 1, 1 (D) 0, 1, 1

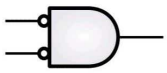
Q.6 Match the logic gates in Column A with their equivalents in Column B. **[GATE 2010, IIT Guwahati]**

Column A		Column B	
P.		1.	
Q.		2.	

R. 

3. 

S. 

4. 

Codes :

	P	Q	R	S
(A)	2	4	1	3
(B)	4	2	1	3
(C)	2	4	3	1
(D)	4	2	3	1

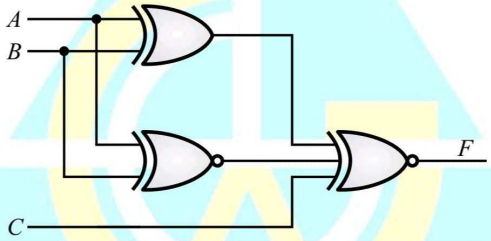
Q.7 Which one of the following expressions does NOT represent exclusive NOR of x and y?

[GATE 2013, IIT Bombay]

(A) xy + x'y' (B) $x \oplus y'$ (C) $x' \oplus y$ (D) $x' \oplus y'$

Q.8 For the output F to be 1 in the logic circuit shown, the input combination should be

[GATE 2010, IIT Guwahati]



(A) $A = 1, B = 1, C = 0$ (B) $A = 1, B = 0, C = 0$

(C) $A = 0, B = 1, C = 0$ (D) $A = 0, B = 0, C = 1$

Q.9 Let $x_1 \oplus x_2 \oplus x_3 \oplus x_4 = 0$ where x_1, x_2, x_3, x_4 are Boolean variables, and $\oplus$ is the XOR operator.

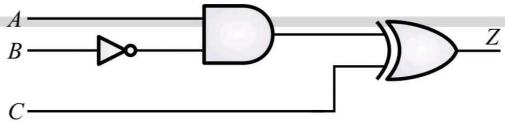
Which one of the following must always be TRUE? **[GATE 2016, IISc Bangalore]**

(A) $x_1 x_2 x_3 x_4 = 0$ (B) $x_1 x_3 + x_2 = 0$

(C) $\overline{x}_1 \oplus \overline{x}_3 = \overline{x}_2 \oplus \overline{x}_4$ (D) $x_1 + x_2 + x_3 + x_4 = 0$

Q.10 Assume that only x and y logic input are available, and their complements $\overline{x}$ and $\overline{y}$ are not available. What is the minimum number of 2-input NAND gates required to implement $x \oplus y$? _____.

Q.11 All the logic gates shown in the figure have a propagation delay of 20 ns. Let $A = C = 0$ and $B = 1$ unit time $t = 0$. At $t = 0$, all the inputs flip (i.e. $A = C = 1$ and $B = 0$) and remain in that state. For $t > 0$, output $Z = 1$ for a duration (in ns) of _____. **[GATE 2015, IIT Kanpur]**



2. Boolean Algebra

Q.1 For the identity $AB + \overline{A}C + BC = AB + \overline{A}C$, the dual form is **[GATE 1998, IIT Delhi]**

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

(C) $(A+B)(\overline{A}+C)(B+C) = (\overline{A}+\overline{B})(A+\overline{C})$ (D) $\overline{A}\,\overline{B} + A\overline{C} + \overline{B}\,\overline{C} = \overline{A}\,\overline{B} + A\overline{C}$

Q.2 The Boolean function $x'y'+xy+x'y$ is equivalent to **[GATE 2004, IIT Delhi]**

(A) $x'+y'$ (B) $x+y$ (C) $x+y'$ (D) $x'+y$

Q.3 If x and y are Boolean variables which one of the following is the equivalent of $x \oplus y \oplus xy$ is

(A) $x+\bar{y}$ (B) $x+y$ (C) 0 (D) 1

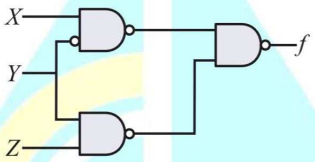
Q.4 Let $\oplus$ denote the exclusive OR(XOR) operation. Let '1' and '0' denote the binary constants. Consider the following Boolean expression for F over two variables *P* and *Q*

$$F(P,Q)=(1\oplus P)\oplus(P\oplus Q)\oplus(P\oplus Q)\oplus(Q\oplus 0)$$

The equivalent expression for *F* is **[GATE 2014, IIT Kharagpur]**

(A) P + Q (B) $\overline{P+Q}$ (C) $P\oplus Q$ (D) $\overline{P\oplus Q}$

Q.5 Consider the following circuit.

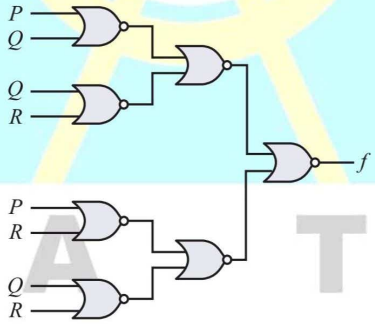


Which one of the following is TRUE? **[GATE 2005, IIT Bombay]**

(A) F is independent of X (B) F is independent of Y

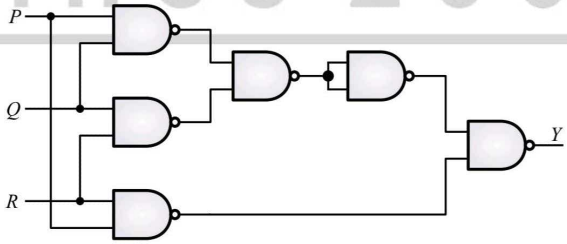
(C) F is independent of Z (D) None of X, Y, Z is redundant

Q.6 What is the Boolean expression for the output f of the combinational logic circuit of NOR gates given below ? **[GATE 2010, IIT Guwahati]**



(A) $\overline{Q+R}$ (B) $\overline{P+Q}$ (C) $\overline{P+R}$ (D) $\overline{P+Q+R}$

Q.7 The output *Y* in the circuit below is always "1" when **[GATE 2011, IIT Madras]**



(A) two or more of the input *P, Q, R* are "0". (B) two or more of the inputs *P, Q, R* are "1".

(C) any odd number of the inputs *P, Q, R* is "0". (D) any odd number of the inputs *P, Q, R* is "1".

Q.8 The Boolean expression $F(X,Y,Z) = \bar{X}\,Y\,\bar{Z} + X\,\bar{Y}\,\bar{Z} + X\,Y\,\bar{Z} + X\,Y\,Z$ converted into canonical product of sum (POS) form is **[GATE 2015, IIT Kanpur]**

(A) $(X+Y+Z)(X+Y+\bar{Z})(X+\bar{Y}+\bar{Z})\,(\bar{X}+Y+\bar{Z})$

(B) $(X+\bar{Y}+Z)(\bar{X}+Y+\bar{Z})(\bar{X}+\bar{Y}+Z)\,(\bar{X}+\bar{Y}+\bar{Z})$

(C) $(X+Y+Z)(\bar{X}+Y+\bar{Z})(X+\bar{Y}+Z)\,(\bar{X}+\bar{Y}+\bar{Z})$

(D) $(X+\bar{Y}+\bar{Z})(\bar{X}+Y+Z)(\bar{X}+\bar{Y}+Z)\,(X+Y+Z)$

Q.9 The product of sum expression of a Boolean function $F(A,B,C)$ of three variables is given by

$$F(A,B,C) = (A+B+\bar{C}).(A+\bar{B}+\bar{C})\ .(\bar{A}+B+C).(\bar{A}+\bar{B}+\bar{C})$$

The canonical sum of product expression of $F(A,B,C)$ is given by **[GATE 2018, IIT Guwahati]**

(A) $\bar{A}\bar{B}C + \bar{A}BC + A\bar{B}\bar{C} + ABC$

(B) $\bar{A}\bar{B}\bar{C} + \bar{A}B\bar{C} + A\bar{B}C + AB\bar{C}$

(C) $AB\bar{C} + A\bar{B}\bar{C} + \bar{A}BC + \bar{A}\bar{B}\bar{C}$

(D) $\bar{A}\bar{B}\bar{C} + \bar{A}BC + AB\bar{C} + ABC$

Q.10 The minterm expansion of $f(P,Q,R) = PQ + Q\bar{R} + P\bar{R}$ is **[GATE 2010, IIT Guwahati]**

(A) $m_2 + m_4 + m_6 + m_7$

(B) $m_0 + m_1 + m_3 + m_5$

(C) $m_0 + m_1 + m_6 + m_7$

(D) $m_2 + m_3 + m_4 + m_5$

Q.11 The simplified SOP (Sum of Product) form of the Boolean expression

$$\left(P+\bar{Q}+\bar{R}\right).\left(P+\bar{Q}+R\right).\left(P+Q+\bar{R}\right)$$

is _____. **[GATE 2011, IIT Madras]**

(A) $\left(\bar{P}.Q+\bar{R}\right)$ (B) $\left(P+\bar{Q}.\bar{R}\right)$ (C) $\left(\bar{P}.Q+R\right)$ (D) $\left(P.Q+R\right)$

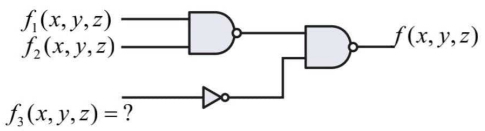
Q.12 For the Boolean expression $f = \bar{a}\bar{b}\bar{c} + \bar{a}b\bar{c} + a\bar{b}\bar{c} + abc + ab\bar{c}$ the minimized Product of sum (POS) expression is **[GATE 2011, IIT Madras]**

(A) $f = (b+\bar{c}).(a+\bar{c})$ (B) $f = (\bar{b}+c).(\bar{a}+c)$ (C) $f = (\bar{b}+c).(a+\bar{c})$ (D) $f = \bar{c} + abc$

Q.13 The Boolean expression X(P, Q, R) = π(0,5) is to be realized using only two 2-input gates. Which are these gates?

(A) AND and OR (B) NAND and OR (C) AND and XOR (D) OR and XOR

Q.14 Consider the following logic circuit whose inputs are function f_1, f_2, f_3 and output is f.



Given that $f_1(x,y,z) = \Sigma(0,1,3,5)$, $f_2(x,y,z) = \Sigma(6,7)$ and $f(x,y,z) = \Sigma(1,4,5)$, f_3 is

[GATE 2002, IISc Bangalore]

(A) Σ (1, 4, 5) (B) Σ (6, 7) (C) Σ (0, 1, 3, 5) (D) None of the above

Digital

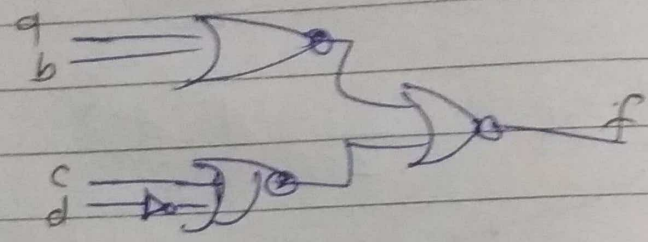
Logic Gates

(1) $Y = AB + CD$

→ 3 NAND Gate Sj 2 i/p

Ans

(2)



(A)

$f = (a+b)(c+\bar{d})$ Ans

(3) $Y = A + BC$

$Y = AA + BC$

→ 3 NAND Gate

Ans

(4) $Z = A\bar{B}C$

$= (AC) \cdot \bar{B}$

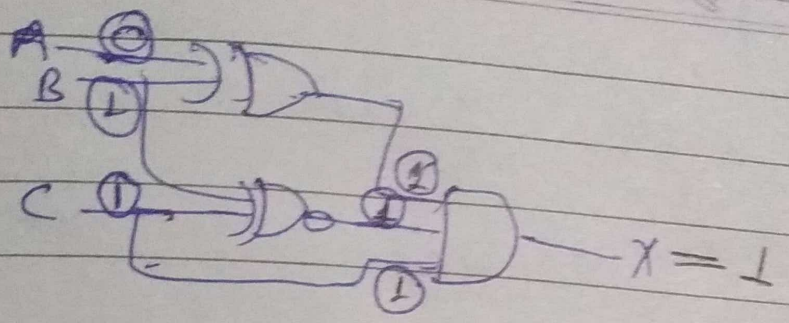
2 NAND

2 NAND

1 NAND

Total = 5 Ans

5



(A, B, C) = 0, 1, 1 Ans

6

A

B

P –

Q –

R –

S –

1 –

2 –

3 –

4 –

P – 4
Q – 2
R – 3
S – 1

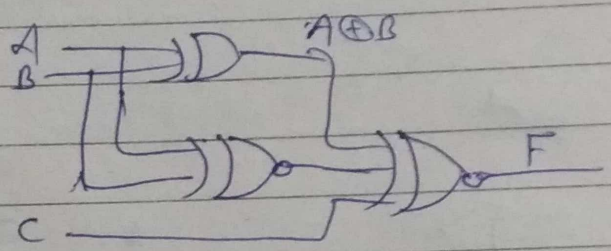
(7) Not XNOR —

(D) $x' \oplus y' = \overline{x \oplus y} = x \oplus y$

→ XOR

(8)

A, B, C



$F = (A \oplus B) \odot (A \odot B) \odot C$

↓

Inequd = 0

$F = 0 \odot C$

$F = \bar{C} \Rightarrow \bar{C} = 1 \Rightarrow C = 0$

(A) — A = 1, B = 1, C = 0

(B) — A = 1, B = 0, C = 0

(C) — A = 0, B = 1, C = 0

9.75

C

$x_1 \oplus x_2 \oplus x_3 \oplus x_4 = 0$

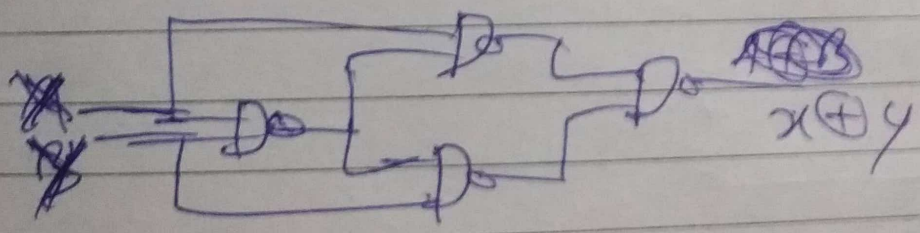
$x_1 \oplus x_3 = x_2 \oplus x_4$

$\overline{x_1 \oplus x_3} = \overline{x_2 \oplus x_4}$

$\boxed{\overline{x_1} \oplus \overline{x_3} = \overline{x_2} \oplus \overline{x_4}}$ Ans

10.75

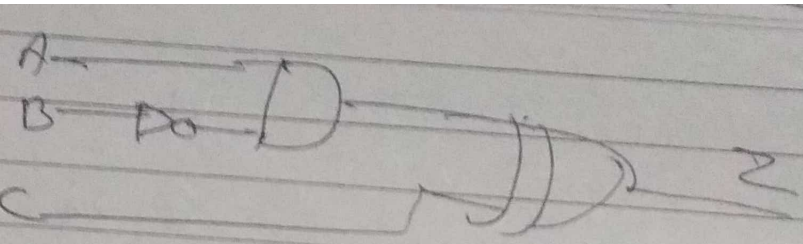
Minimum 2-I/P NAND → $x \oplus y$



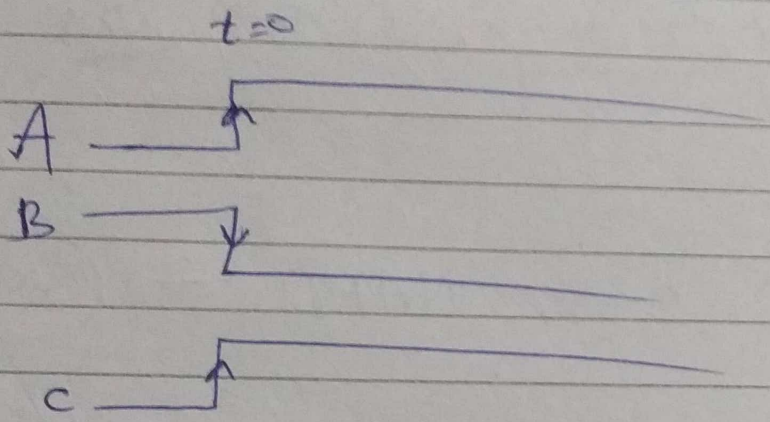
Minimum = 9 Ans

(11) →

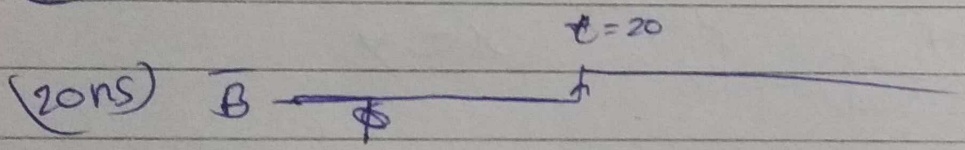
Ans



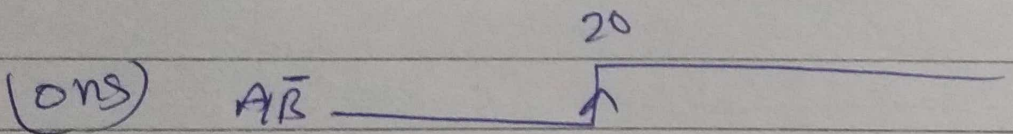
$A = C = 1, \quad B = \bar{0}$



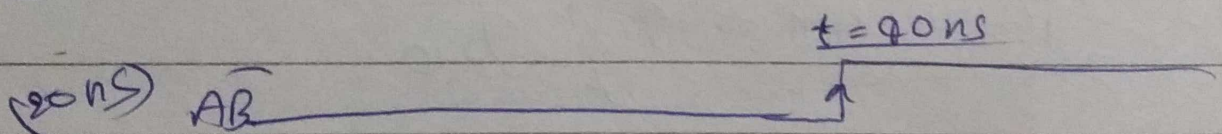
(0ns) $\bar{B}$



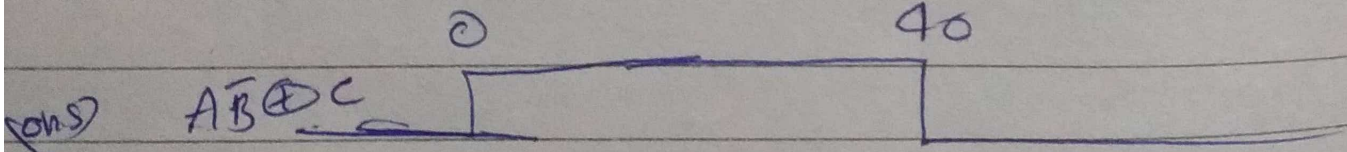
(20ns) $\bar{B}$



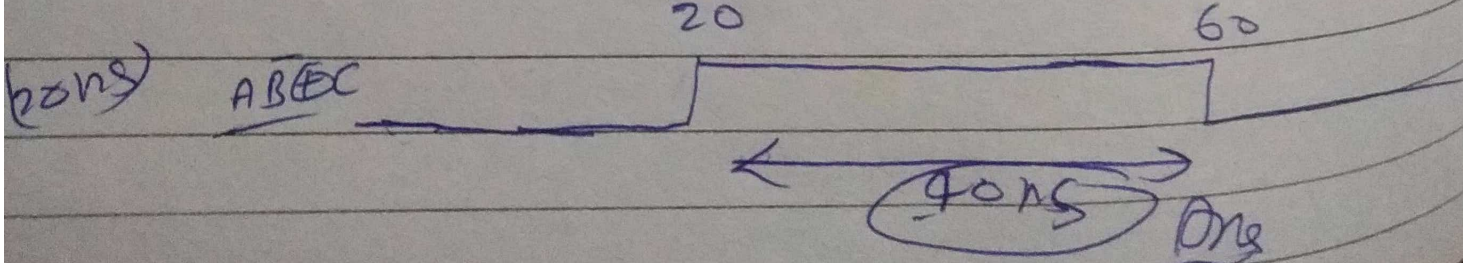
(0ns) $A\bar{B}$



(20ns) $A\bar{B}$



(0ns) $A\bar{B} \oplus C$



(20ns) $AB \oplus C$

Boolean Algebra

(1) $AB + \bar{A}C + BC = AB + \bar{A}C$

(A) .Apply dual

$(A+B)\cdot(\bar{A}+C)(B+C) = (A+B)(\bar{A}+C)$

(2) $\bar{x}\bar{y} + xy + \bar{x}y$

(D)

$\bar{x}\bar{y} + \bar{x}y + xy + \bar{x}y$

$\bar{x}(\bar{y}+y) + y(x+\bar{x})$

$= \bar{x} + y$ Ans

(3) $x \oplus y \oplus xy$

(B)

$\overline{(x \oplus y)xy + (x \oplus y)\overline{xy}}$

$\overline{(xy + \bar{x}\bar{y})xy + (\bar{x}y + x\bar{y})(\bar{x} + \bar{y})}$

$\overline{xy + \bar{x}y + x\bar{y}}$

$x + y$ Ans

4 → $(1 \oplus P) \oplus (P \oplus Q) \oplus (P \oplus Q) \oplus (Q \oplus 0)$

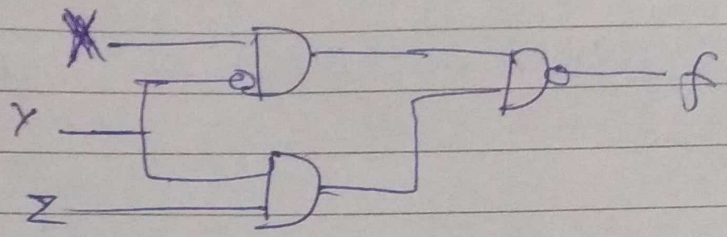
D

$\bar{P} \oplus 0 \oplus Q$

$\bar{P} \oplus Q$

$= \overline{P \oplus Q}$

5 →



D

$f = x\bar{y} + yz$

→ Independent, x, y, z

---

6 → $Q + PR + P + PQ$

A

$= \overline{Q + R}$ Ans

7 → $Y = PQ + QR + PR$

B

→ Two or more of the i/p P, Q, R are '1'

(8) $F = \bar{x}y\bar{z} + x\bar{y}\bar{z} + xy\bar{z} + xyz$

(A) $= \Sigma m(010, 100, 110, 111)$

$= \Sigma m(2, 4, 6, 7)$

$= \pi M(1, 3, 5)$

$= \pi M(000, 001, 011, 101)$

$F = (X+Y+Z)(X+Y+\bar{Z})(X+\bar{Y}+\bar{Z})(\bar{X}+Y+\bar{Z})$

Ans

(9) $F = (A+B+\bar{C})(A+\bar{B}+\bar{C})(\bar{A}+B+\bar{C})(\bar{A}+\bar{B}+\bar{C})$

(B) $= \pi M(001, 011, 100, 111)$

$= \pi M(1, 3, 4, 7)$

$= \Sigma m(0, 2, 5, 6)$

$= \Sigma m(000, 010, 101, 110)$

$F = \bar{A}\bar{B}\bar{C} + \bar{A}B\bar{C} + A\bar{B}C + AB\bar{C}$

Ans

(10) $f = PQ + QR + P\bar{R}$

(A)

$11X \quad X10 \quad 1X0$

$110 \quad 010 \quad 100$

$111 \quad 110 \quad 110$

$6 \& 7 \quad 2 \& 6 \quad 4 \& 6$

2, 4, 6, 7

$m_2 + m_4 + m_6 + m_7$ Ans

(11) $(P + \bar{Q} + R)(P + \bar{Q} + \bar{R})(P + Q + \bar{R})$

(B) $= (P + \bar{Q} + \bar{R} \cdot R)(P + Q + \bar{R})$

$= (P + \bar{Q})(P + Q + \bar{R})$

$= P + \bar{Q}(Q + \bar{R})$

$P + \bar{Q}\bar{R}$ Ans

(12) $f = \bar{a}\bar{b}\bar{c} + \bar{a}b\bar{c} + \cancel{abc} + ab\bar{c} + a\bar{b}\bar{c}$

(A)

$= \bar{c}(\bar{a}\bar{b} + \bar{a}b + ab + a\bar{b}) + abc$

$= \bar{c} \cdot 1 + abc$

$= (\bar{c}+a)(\bar{c}+b)(\bar{c}+c)$

$= (a+\bar{c})(b+\bar{c})$ Ans

(13) $X = \pi(0,5)$

(D)

$\rightarrow \pi M\ (000, 101)$

$= (P+Q+R)(\bar{P}+Q+\bar{R})$

$= Q + (P+R)(\bar{P}+\bar{R})$

$= Q + (P\bar{R} + R\bar{P})$

$= Q + (P \oplus R)$

OR & XOR

(14) f_1 0,3,5 → 0,1,2,3,4,5,6,7

f_2 6,7

f_3 → 0,2,3,6,7

$f = 1,4,5$

(A)

1,4,5 Ans