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DIGITAL LOGIC

COMPUTER SCIENCE & IT

Date of Test : 25/09/2025

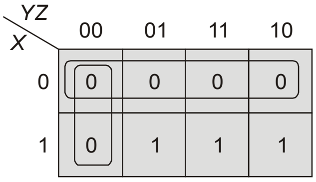
ANSWER KEY

1.	(c)	7.	(b)	13.	(c)	19.	(b)	25.	(d)
2.	(a)	8.	(b)	14.	(c)	20.	(c)	26.	(d)
3.	(c)	9.	(c)	15.	(b)	21.	(b)	27.	(d)
4.	(c)	10.	(b)	16.	(a)	22.	(c)	28.	(a)
5.	(d)	11.	(d)	17.	(c)	23.	(c)	29.	(b)
6.	(d)	12.	(a)	18.	(d)	24.	(c)	30.	(c)

DETAILED EXPLANATIONS

1. **(c)**

From the options it can be seen that for the option (c), we get



YZ \ X	00	01	11	10
0	0	0	0	0
1	0	1	1	1

Thus,
$$f = X(Y+Z)$$
$$= XY + XZ$$

2. **(a)**

The output logic function of the given circuit can be expressed as,

$$f = \overline{\left(\overline{(\overline{AB})C}\right)\left(\overline{\overline{C}D}\right)}$$
$$= (\overline{AB})C + \overline{C}D$$
$$= (\overline{A} + \overline{B})C + \overline{C}D$$

3. **(c)**

Let binary number N is given to the system then,

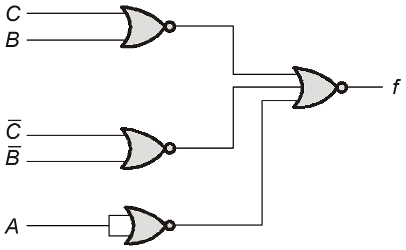
$$Y = \text{1's of N} + \underbrace{\text{2's of N}}$$
$$= \text{1's of N} + \underbrace{\text{1's of N} + 1}$$
$$= N + 1$$

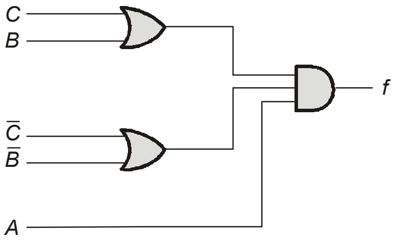
3 such systems are cascaded.

$$\text{So final output} = \text{Input} + (3)_{10}$$
$$= 1010 + 0011$$
$$= 1101$$

4. **(c)**

The above circuit can be drawn as,

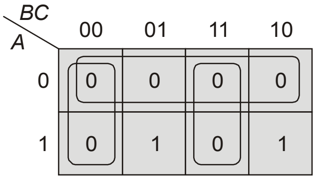




From the above figure, we can write,

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

The output is in POS form, we can use this expression to fill the *K*-map.



Thus from the figure, we can deduce

$$f(A, B, C) = \Sigma m\,(5, 6)$$

5. **(d)**

DEMUX can not be used as an universal gate. This is because a universal gate is one that can be used to implement any Boolean function, whereas a DEMUX can only implement a specific type of function.

In contrast, gates such as NAND and NOR are considered universal gates. This is due to the fact that both NAND and NOR gates can be used to construct all the other fundamental logic gates (AND, OR, NOT).

6. **(d)**

$$\begin{aligned} 2r + 3 + 4r + 4 + r + 4 + 3r + 2 &= 2r^2 + 2r + 3 \\ 10r + 13 &= 2r^2 + 2r + 3 \\ 2r^2 - 8r - 10 &= 0 \\ r^2 - 4r - 5 &= 0 \\ r &= 5, -1 \end{aligned}$$

$\because$ Radix cannot be negative

$\therefore$ $r = 5$

7. **(b)**

In J-K flip-flop

J	K	Output
1	0	Set
0	1	Reset
0	0	Hold
1	1	Race around

8. **(b)**

				FF2		FF1		FF0
CLK	Q_2	Q_1	Q_0	$J = \bar{Q}_0$	$K = 1$	$X = Q_2$	$Y = Q_0$	$D = Q_1$
	0	0	1	0	1	0	1	0
1	0	1	0	1	1	0	0	1
2	1	1	1	0	1	1	1	1
3	0	1	1	0	1	0	1	1
4	0	0	1					

$\therefore$ Counter is back to the initial state after 4 clock pulses.

9. **(c)**

We know that, for Mod-N counter $f_o = \frac{f_i}{N}$

$$f_o = \text{Output frequency} = 8\text{ kHz}$$
$$f_i = \text{Input frequency} = 256\text{ kHz}$$
$$\text{Mod N} = \frac{f_i}{f_0} = \frac{256\text{ kHz}}{8\text{ kHz}} = 32$$

10. **(b)**

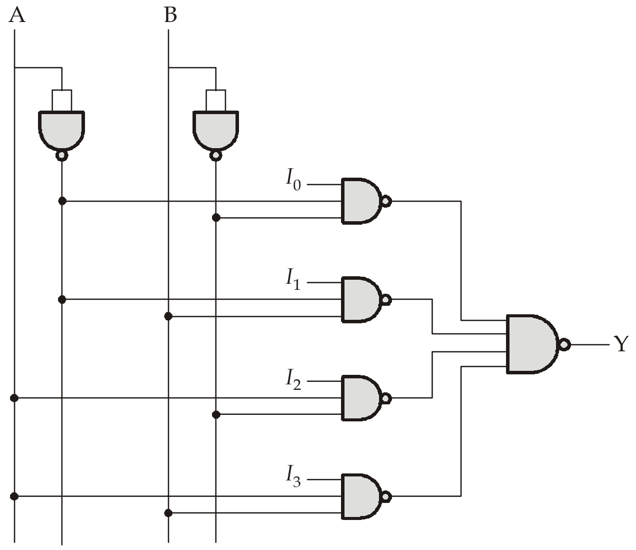
According to the given number, the least value of 'x' can be

'12 + 1' = 13

Therefore, the least decimal equivalent

$$= (13)^2 + 10 \times 13 + 12 = 311$$

11. **(d)**



12. **(a)**

$$Y = \bar{S}_1\bar{S}_0(I_0) + \bar{S}_1S_0(I_1) + S_1\bar{S}_0(I_2) + S_1S_0(I_3)$$
$$I_0 = I_3 = S_1$$
$$I_1 = I_2 = S_0$$

$$\Rightarrow \qquad Y = \underbrace{\bar{S}_1\bar{S}_0(S_1)}_{0} + \bar{S}_1S_0(S_0) + \underbrace{S_1\bar{S}_0(S_0)}_{0} + S_1S_0(S_1)$$

$$Y = \bar{S}_1S_0 + S_1S_0$$

- $S_0 = B$, $S_1 = A$

$$Y = \bar{A}B + AB = (\bar{A} + A)B = B$$

- $S_0 = A$, $S_1 = \bar{B}$

$$Y = \bar{\bar{B}}A + \bar{B}A = BA + \bar{B}A = A(B + \bar{B}) = A$$

- $S_0 = \bar{A}$, $S_1 = B$

$$Y = \bar{B}\bar{A} + B\bar{A} = \bar{A}(B + \bar{B}) = \bar{A}$$

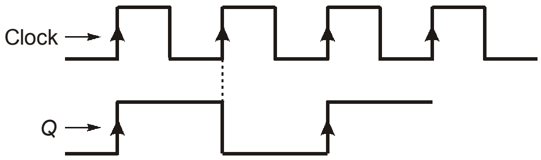
- $S_0 = \bar{A}, S_1 = \bar{B}$

$$Y = \bar{A}\bar{\bar{B}} + \bar{B}\bar{A} = \bar{A}B + \bar{B}\bar{A} = \bar{A}(B + \bar{B}) = \bar{A}$$

Hence option (a) is the correct answer.

13. **(c)**

J-K flip-flop is in toggle node so after every clock pulse output Q toggles. So output Q will be as



and Q is input to MOD-3 counter then

after 3 clock pulses of input clock there are 2 +ve edge of clock input Q so output of counter goes to 2 = $(10)_2$

So, $AB = 10$

So, Q, A and B respectively is 110.

14. **(c)**

A	B	J	K	Q_{n+1}
0	0	1	0	1
0	1	1	1	$\bar{Q}_n$
1	0	1	0	1
1	1	0	1	0

$$Q_{n+1} = \bar{A}\bar{B} + A\bar{B} + \bar{A}B\bar{Q}_n$$

$$Q_{n+1} = \bar{B} + \bar{A}B\bar{Q}_n$$

$$= \bar{B} + \bar{A}\bar{Q}_n$$

15. **(b)**

$$Y = I_0 \cdot \bar{S}_1\,\bar{S}_0 + I_1 \cdot \bar{S}_1\,S_0 + I_2 \cdot S_1\,\bar{S}_0 + I_3\,S_1\,S_0$$

$$Y = A\bar{B} + (1)\,B = B + A\bar{B} = A + B$$

16. **(a)**

State table can be drawn from state diagram

Present state	Input	Next state
Q_n	X	Q_{n+1}
0	1	0
0	0	1
1	1	0
1	0	0

$$Q_{n+1} = \overline{Q_n + X}$$ (Q_{n+1} represent output of NOR gate)

17. **(c)**

The ring counter, Johnson counter (twisted ring counter) are working as MOD 2 counters for the given initial states. So we can plot the response against the enable input as

Clock	Enable	Ring Counter	Johnson Counter
1	0	1010	101
2	1	0101	010
3	0	1010	101
⋮	⋮	⋮	⋮

Thus for every even clock pulse, the output is 0101010. So the LEDs b,d, f will be ON and the output displayed will be 7.

18. **(d)**

We know that for a stage change to ripple through n stages i.e. $T_C = n \times t_{pd}$.

$$f_c = \frac{1}{T_C}$$

$$f_c = \frac{1}{n \times t_{pd}}$$

So,
$$t_{pd} = \frac{1}{n \times f_c}$$

$$\begin{aligned} t_{pd}(\text{min}) &= \frac{1}{10 \times 10 \times 10^6 \text{Hz}} \\ &= 0.01 \times 10^{-6} \text{ sec} \\ &= 10 \times 10^{-9} \text{ sec} \\ &= 10 \text{ nsec} \end{aligned}$$

19. **(b)**

The given 2's complement number

⇒ 101010101.0101 sign bit is 1, number is negative.
↑
010101010.1011

Magnitude is $(010101010.1011)_2 = (170.6875)_{10}$

∴ Value = –170.6875

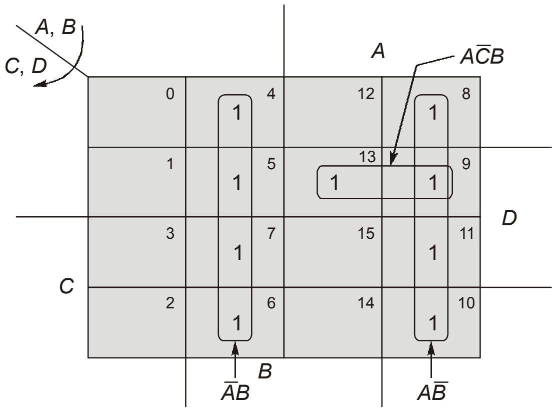
20. **(c)**

$$f(A, B, C, D) = \Sigma m\ (1, 4, 5, 8, 10, 12, 14, 15) \quad \text{...(1)}$$

$$f_2(A, B, C, D) = \bar{A}B + A\bar{B} + A\bar{C}D$$

Identify the minterms using K-map for the function f_2.

$$f_2(A, B, C, D) = (4, 5, 6, 7, 8, 9, 10, 11, 13) \quad \text{...(2)}$$



Compare equation (2) and (1) for common minterms.

Common minterms are (4, 5, 8, 10)

(4, 5, 8, 10) minterms are contributed to the function *f*, by the AND gate.

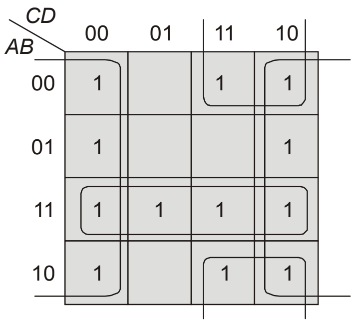
So that function $\overline{f}_3(A,B,C,D) = \Sigma m\ (1, 12, 14, 15) + d\ (4, 5, 8, 10)$

21. **(b)**

Since number *B* is 15 thus its 4 bit binary equivalent $(B_3B_2B_1B_0)$ will be 1111. Thus the addend will be 0000 and augend will be 1001. The output of the parallel adder will be

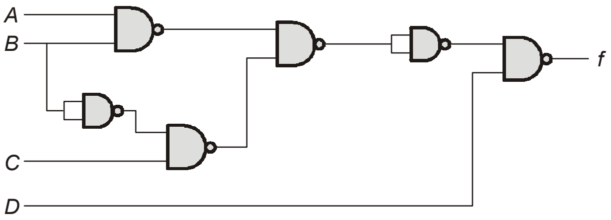
$$\begin{aligned}\text{Output} &= \text{addend} + \text{augend} + C_{\text{in}}\\ &= 0000 + 1001 + 1\\ &= 1010\end{aligned}$$

22. **(c)**



From the *K*-map, we have,

$$f = \overline{D} + AB + \overline{B}C$$



23. **(c)**

$$f = \bar{S}_1 \bar{S}_0 \bar{I}_0 + \bar{S}_1 S_0 I_1 + S_1 \bar{S}_0 I_2 + S_1 S_0 I_3$$

Now, $S_1 = B, S_0 = A, I_0 = D, I_1$

$$= (\overline{C+D}) = \bar{C}\,\bar{D},\ I_2 = CD \text{ and } I_3 = 1$$

$\therefore$ $f = \bar{B}\,\bar{A}\,D + \bar{B}\,A\,\bar{C}\,\bar{D} + B\,\bar{A}\,C\,D + AB$

Expressing the boolean function in canonical form by using *K*-map, we get,

AB \ CD	00	01	11	10
00	0 0	1 1	3 1	2 0
01	4 0	5 0	7 1	6 0
11	12 1	13 1	15 1	14 1
10	8 1	9 0	11 0	10 0

$$f(A, B, C, D) = \Pi M\,(0, 2, 4, 5, 6, 9, 10, 11)$$

24. **(c)**

$$\begin{aligned} F &= A(\bar{A}+B)(\bar{A}+B+\bar{C}) \\ &= (A+B\bar{B}+C\bar{C})(\bar{A}+B+C\bar{C})(\bar{A}+B+\bar{C}) \\ &= (A+B+C)(A+B+\bar{C})(A+\bar{B}+C)(A+\bar{B}+\bar{C})(\bar{A}+B+C)(\bar{A}+B+\bar{C}) \end{aligned}$$

$$\begin{aligned} \text{POS (F)} &= M_0, M_1, M_2, M_3, M_4, M_5 \\ &= \Pi(0, 1, 2, 3, 4, 5) \end{aligned}$$

So, $\text{SOP (F)} = (0, 1, 2, 3, 4, 5, 6, 7) - (0, 1, 2, 3, 4, 5)$

$$= \Sigma(6, 7)$$

So, $F = \Sigma(6, 7)$ and $F = \Pi(0, 1, 2, 3, 4, 5)$

25. **(d)**

(a)

$$\begin{aligned} \overline{(\bar{A}B+\bar{C})}(A+C) &= (A+\bar{B})C \\ (A+\bar{B})\cdot C\cdot(A+C) &= (A+\bar{B})C \\ (AC+\bar{B}C)(A+C) &= (A+\bar{B})C \\ AC+A\bar{B}C+\bar{B}C &= (A+\bar{B})C \\ AC+\bar{B}C &= (A+\bar{B})C \\ (A+\bar{B})C &= (A+\bar{B})C \quad \because \text{True} \end{aligned}$$

(b)

$$\begin{aligned} \overline{(A+\bar{B}+\bar{C})(A+\bar{B}C)} &= \bar{A}(B+\bar{C}) \\ (\bar{A}BC)+\bar{A}(B+\bar{C}) &= \bar{A}B+\bar{A}\bar{C} \\ \bar{A}BC+\bar{A}B+\bar{A}\bar{C} &= \bar{A}B+\bar{A}\bar{C} \\ \bar{A}B(C+1)+\bar{A}\bar{C} &= \bar{A}B+\bar{A}\bar{C} \\ \bar{A}\bar{C}+\bar{A}B &= \bar{A}B+\bar{A}\bar{C} \quad \because \text{True} \end{aligned}$$

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

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

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

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

$$B = B \quad \because \text{ True}$$

So, all the expression are correct.

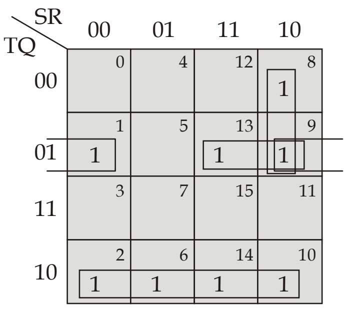
26. **(d)**

			FFD	FFT
	Q_D	Q_T	$D = \bar{Q}_T$	$T = \bar{Q}_T \oplus Q_D$
Clock pulse	0	0	1	1
1	1	1	0	1
2	0	0	1	1
3	1	1	0	1
4	0	0		

So, output will either be 00 or 11 and never 10.

27. **(d)**

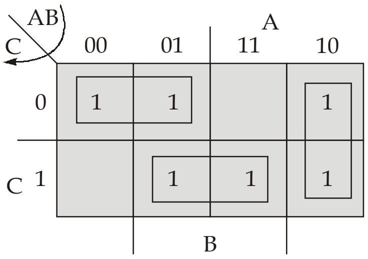
S	R	T	Q	Q^+
0	0	0	0	0
0	0	0	1	1
0	0	1	0	1
0	0	1	1	0
0	1	0	0	0
0	1	0	1	0
0	1	1	0	1
0	1	1	1	0
1	0	0	0	1
1	0	0	1	1
1	0	1	0	1
1	0	1	1	0
1	1	0	0	0
1	1	0	1	1
1	1	1	0	1
1	1	1	1	0



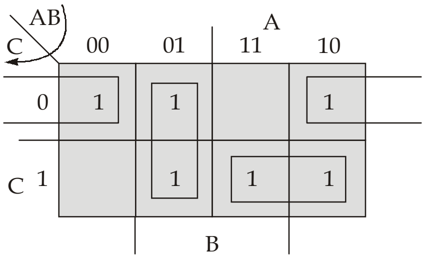
$$Q^+ = TQ' + T'QS + T'QR' + T'SR'$$
$$= TQ' + T'[Q(S + R') + SR']$$

28. (a)

Example: $F(A, B, C) = \Sigma m(0, 2, 3, 4, 5, 7)$



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



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

F(A, B, C) is having cyclic PI K-map and it is having '2' minimal forms.
In general, based on above example when the Boolean function is having cyclic prime implicants K-map it will be having 2 minimal forms.

29. (b)

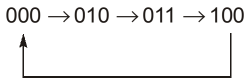
The given circuit represents a 3-bit counter. So the count can be represented as

Clk	Q_2	Q_1	Q_0	
Initially	0	0	0	
1	0	0	1	
2	0	1	0	
3	0	1	1	
4	1	0	0	
5	1	0	1	⇒ 5th clock pulse
6	1	1	0	
7	1	1	1	

$$\therefore \quad Y = Q_2 \oplus Q_1 \oplus Q_0$$
$$= 1 \oplus 0 \oplus 1 = 0$$

30. (c)

Clk	Q_A	Q_B	Q_C	$D_A = Q_C$	$D_B = \overline{Q_A + Q_C}$	$D_C = Q_B\overline{Q_C}$
0	0	0	0	0	1	0
1	0	1	0	0	1	1
2	0	1	1	1	0	0
3	1	0	0	0	0	0



⇒ 4 distinct states

■■■■