IIITB COMET FOUNDATION

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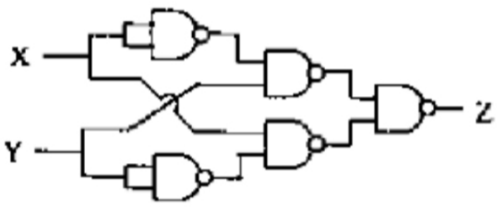
QUESTION

The logic gate circuit shown in the adjoining figure realizes which of the following function?

1. XOR
2. XNOR
3. Half Adder
4. Full Adder



SOLUTION

Step 1: Identification of Gates

From the circuit diagram, all the gates used are NAND gates. A NAND gate performs the Boolean operation:

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

Since NAND is a universal gate, any Boolean function can be implemented using only NAND gates.

Step 2: First Stage Operation

If both inputs of a NAND gate are same, it acts as an inverter:
X NAND $X = \overline{X}$
Y NAND $Y = \overline{Y}$
Thus, we obtain complemented inputs:
$\overline{X}$ and $\overline{Y}$

Step 3: Intermediate Stage
The cross-connected NAND gates generate:
$P = \overline{X \cdot \overline{Y}}$
$Q = \overline{\overline{X} \cdot Y}$

Step 4: Final Stage
The final NAND gate gives:
$Z = \overline{P \cdot Q}$
Substituting values of P and Q:
$Z = \overline{\left(\overline{X \cdot \overline{Y}}\right) \cdot \left(\overline{\overline{X} \cdot Y}\right)}$
Using De Morgan's Theorem and Boolean simplification:
$Z = X\overline{Y} + \overline{X}Y$

Step 5: Final Result
The expression $Z = X\overline{Y} + \overline{X}Y$ is the standard form of the Exclusive-OR function.
Therefore,
$Z = X \oplus Y$

Conclusion:
The given circuit realizes the XOR function.

Correct Answer: (a) XOR