Q1

Inputs			Outputs	
A	B	C	Sum	Carry
0	0	0	0	0
0	0	1	1	0
0	1	0	1	0
0	1	1	0	1
1	0	0	1	0
1	0	1	0	1
1	1	0	0	1
1	1	1	1	1

By K map we can derive equation

for sum

A \ BC	$\bar{B}\bar{C}$	$\bar{B}C$	BC	$B\bar{C}$
$\bar{A}$	0	1 1	3	1 2
A	1 4	5	1 7	6

$$= A\bar{B}\bar{C} + \bar{A}\bar{B}C + ABC + \bar{A}B\bar{C}$$

$$S = A \oplus B \oplus C$$

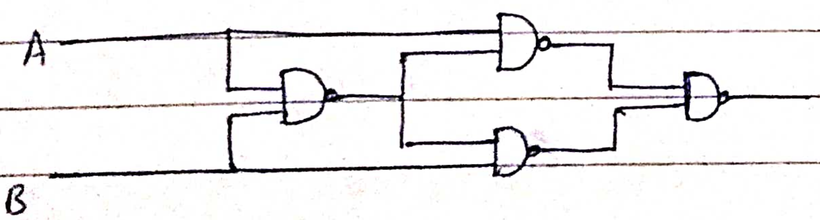
for carry.

A \ BC	$\bar{B}\bar{C}$	$\bar{B}C$	BC	$B\bar{C}$
$\bar{A}$	0	1	$\boxed{1}$ 3	2
A	4	$\boxed{1}$ 5	$\boxed{1}$ 7	$\boxed{1}$ 6

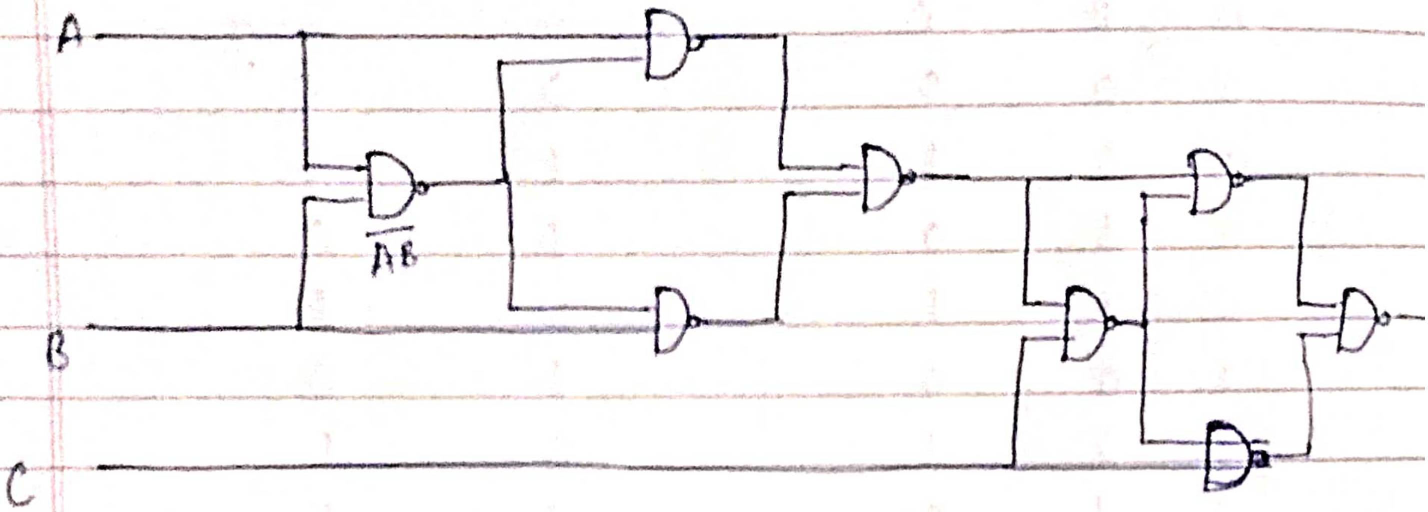
$$C = AC + AB + BC$$

$$= AB + BC + CA$$

So nand equivalent of Xor gate is



So, $A \oplus B \oplus C$



Sum = $A \oplus B \oplus C$

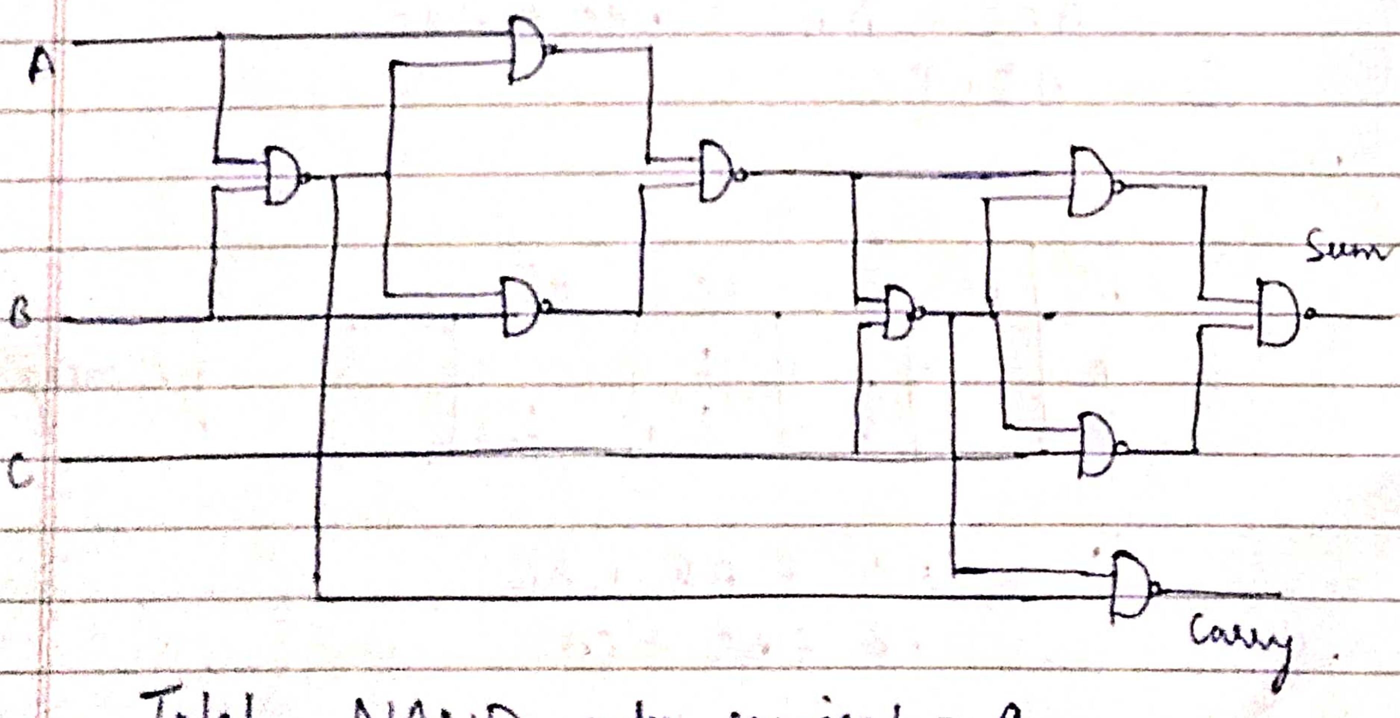
Carry $= AB + BC + CA$

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

$= \overline{\overline{AB} \cdot \overline{C(A \oplus B)}}$

Both these terms are present in above circuit

So,



Total NAND gates required = 9

Q2

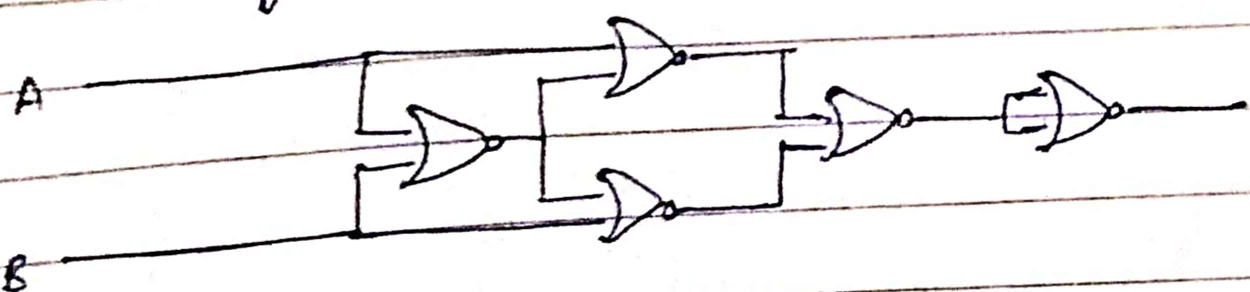
Input			Output	
A	B	Borrow$(C)_{in}$	Diff	Borrow
0	0	0	0	0
0	0	1	1	1
0	1	0	1	1
0	1	1	0	1
1	0	0	1	0
1	0	1	0	0
1	1	0	0	0
1	1	1	1	1

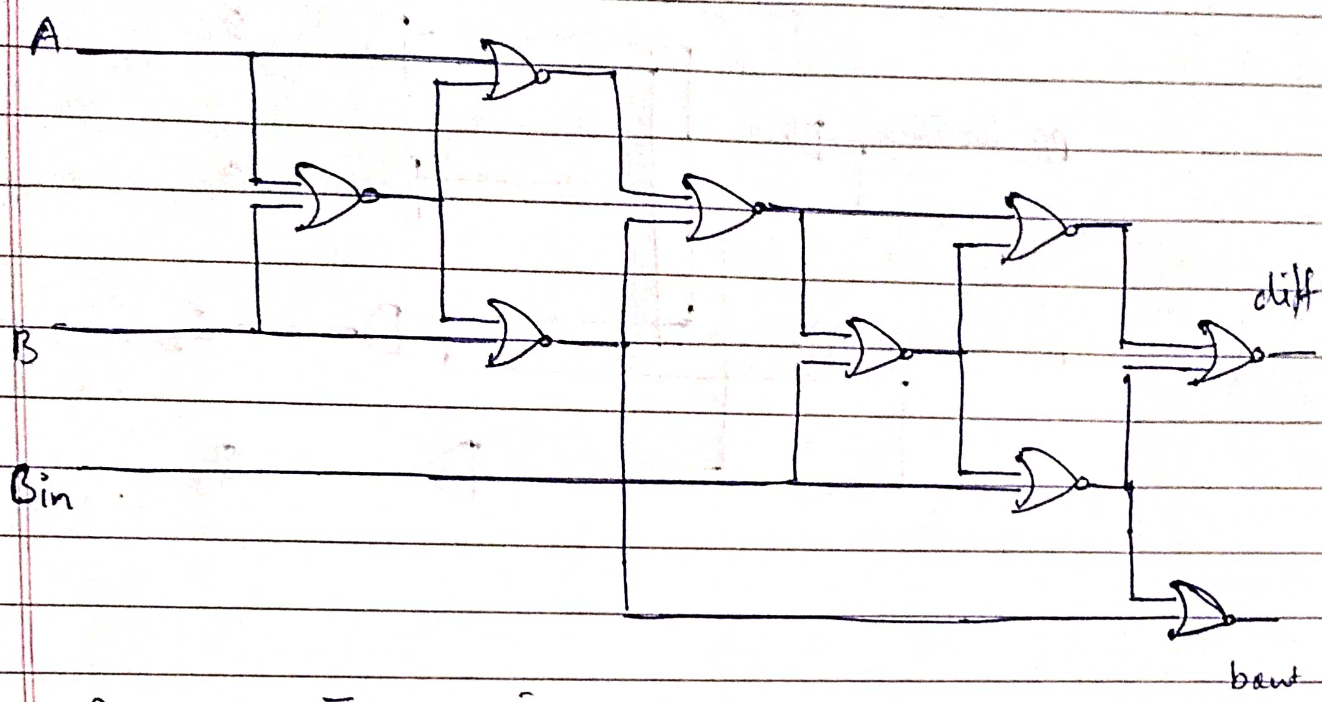
A \ BC	$\bar{B}\bar{C}$	$\bar{B}C$	BC	$B\bar{C}$
$\bar{A}$	$_{0}$	1_{1}	$_{3}$	1_{2}
A	1_{4}	$_{5}$	1_{7}	$_{6}$

$$Diff = A \oplus B \oplus B_{in}$$

Let $X = A \oplus B$

by NOR gate





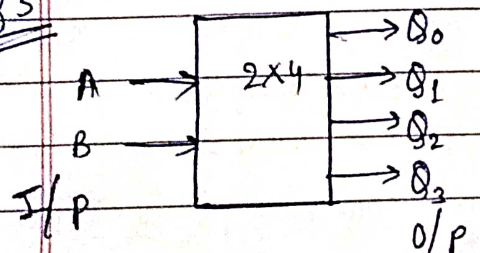
$$B_{out} = \bar{A}B_{in} + \bar{A}B + BB_{in}$$

$$= (A \oplus B + B_{in}) \cdot (\overline{A\bar{B}})$$

$$= \overline{A \oplus B} \cdot \overline{B_{in}} + A\bar{B}$$

Total number of NOR gates = 9.

Q3



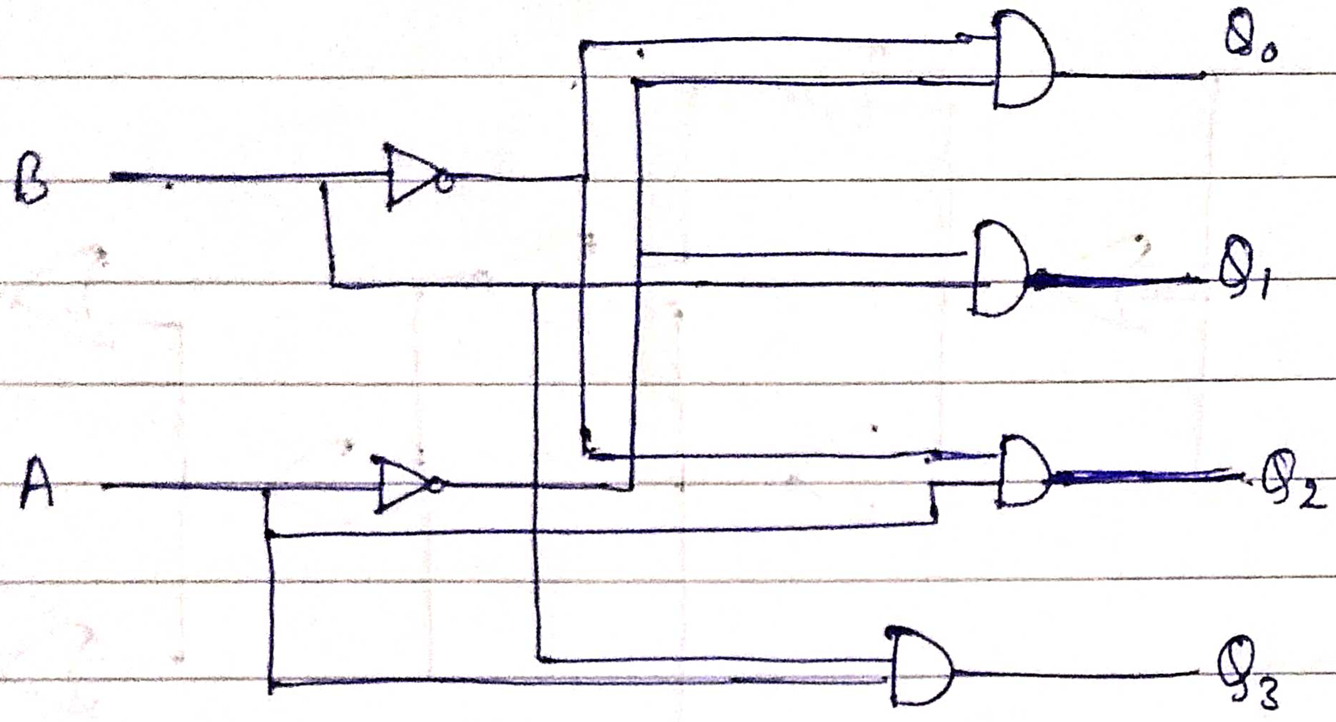
A	B	Q_0	Q_1	Q_2	Q_3
0	0	1	0	0	0
0	1	0	1	0	0
1	0	0	0	1	0
1	1	0	0	0	1

K map for Q_0

A \ B	$\bar{B}$	B
$\bar{A}$	1 (0)	(1)
A	(2)	(3)

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

similarly, $Q_1 = \bar{A}B$. $Q_2 = A\bar{B}$, $Q_3 = AB$


B
A
Q0
Q1
Q2
Q3