1) A)

$A = \bar{a}bc + a\bar{b}c + ab\bar{c} + abc$

∇ Adding abc will not change result.

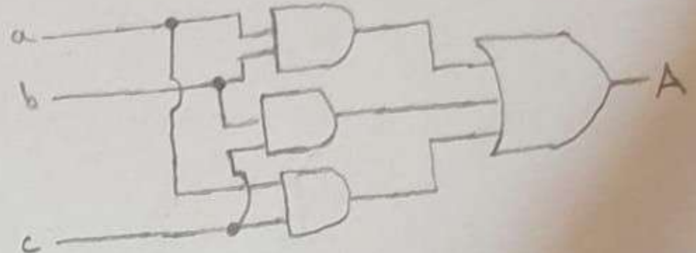
$A = \bar{a}bc + a\bar{b}c + ab\bar{c} + abc + abc + abc$

$A = ac(\bar{b}+b) + ab(\bar{c}+c) + bc(\bar{a}+a)$

$\boxed{A = ac + ab + bc}$

a	b	c	A	
0	0	0	0	
0	0	1	0	
0	1	0	0	
0	1	1	1	✓ $\bar{a}bc$
1	0	0	0	
1	0	1	1	✓ $a\bar{b}c$
1	1	0	1	✓ $ab\bar{c}$
1	1	1	1	✓ abc

Truth Table



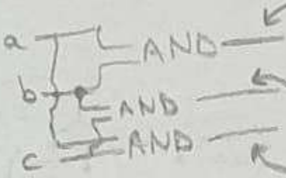
1) B)

$\boxed{A = ac + ab + bc}$

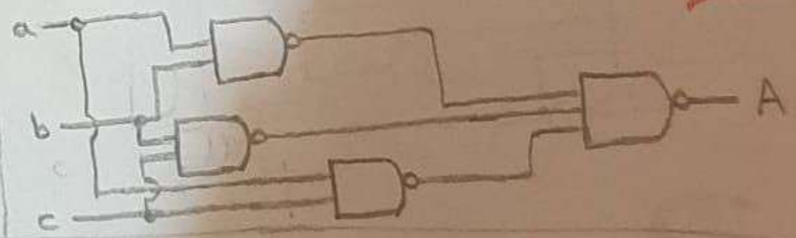
A \ BC	00	01	11	10
0	0	0	1	0
1	0	1	1	1

This is karnough map.
There are 3 groups in total.

$A = ac + bc + ab$



If we insert those NOT's, AND gates have become NAND gates. We have 3 NOT and 1 OR left. $A+B = (A' \cdot B')'$ using de morgan's law. (OR gate, AND gate, NAND gate)
The relation between OR gate and NAND gate has been shown.



2) B)

Truth table of G

a	b	c	d	G
0	0	0	0	1
0	0	0	1	1
0	0	1	0	1
0	0	1	1	0
0	1	0	0	1
0	1	0	1	1
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	0
1	1	1	0	0
1	1	1	1	0

Truth table of F

a	b	c	d	F
0	0	0	0	0
0	0	0	1	0
0	0	1	0	0
0	0	1	1	1
0	1	0	0	0
0	1	0	1	0
0	1	1	0	0
0	1	1	1	1
1	0	0	0	0
1	0	0	1	0
1	0	1	0	0
1	0	1	1	1
1	1	0	0	1
1	1	0	1	1
1	1	1	0	1
1	1	1	1	1

∇ As seen, G and F are output columns and are not equal to each other.

Therefore, the two circuits are not equivalent circuits.

2) A)

ab \ cd	00	01	11	10
00	1	1	0	1
01	1	1	0	1
11	0	0	0	0
10	1	1	0	1

Karnaugh map belongs to the circuit whose output is G.

There are four 1s groups.

$$G = \bar{a}\bar{c} + \bar{a}\bar{d} + \bar{b}\bar{c} + \bar{b}\bar{d}$$

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

$$\boxed{G = (\bar{c}+\bar{d}).(\bar{a}+\bar{b})}$$

ab \ cd	00	01	11	10
00	0	0	1	0
01	0	0	1	0
11	1	1	1	1
10	0	0	1	0

Karnaugh map belongs to the circuit whose output is F.

There are two 1s groups.

$$\boxed{F = cd + ab}$$

$G \neq F$

They are opposite of each other.

They are not equivalent circuits.

3)

a	b	c	d	F	
0	0	0	0	1	0 is even
0	0	0	1	0	
0	0	1	0	0	
0	0	1	1	1	2 is even
0	1	0	0	0	
0	1	0	1	1	2 is even
0	1	1	0	1	2 is even
0	1	1	1	0	
1	0	0	0	0	
1	0	0	1	1	2 is even
1	0	1	0	1	2 is even
1	0	1	1	0	
1	1	0	0	1	2 is even
1	1	0	1	0	
1	1	1	0	0	
1	1	1	1	1	4 is even

Truth Table of circuit

AB \ CD	00	01	11	10
00	1	0	1	0
01	0	1	0	1
11	1	0	1	0
10	0	1	0	1

Karnaugh map belongs to the circuit.

XOR boolean expression $\bar{a}b + \bar{b}a$

XNOR boolean expression $\bar{a}\bar{b} + ab$

$$F = \bar{a}\bar{b}\bar{c}\bar{d} + \bar{a}\bar{b}cd + \bar{a}b\bar{c}d + \bar{a}bc\bar{d} + a\bar{b}\bar{c}d + a\bar{b}c\bar{d} + ab\bar{c}\bar{d} + abcd$$

$$F = \bar{a}\bar{b}(\bar{c}\bar{d} + cd) + \bar{a}b(\bar{c}d + c\bar{d}) + a\bar{b}(\bar{c}d + c\bar{d}) + ab(\bar{c}\bar{d} + cd)$$

$$F = \bar{a}\bar{b}(\overline{c \oplus d}) + \bar{a}b(c \oplus d) + a\bar{b}(c \oplus d) + ab(\overline{c \oplus d})$$

$$(c \oplus d)(a\bar{b} + \bar{a}b) + (\overline{c \oplus d})(\bar{a}\bar{b} + ab)$$

$$\underbrace{(c \oplus d)}_{Y}\underbrace{(a \oplus b)}_{X} + \underbrace{(\overline{c \oplus d})}_{Y'}\underbrace{(\overline{a \oplus b})}_{X'}$$

$$XY + X'Y' = \overline{(X \oplus Y)} \qquad X \oplus 1 = X'$$

$$F = \overline{(a \oplus b) \oplus (c \oplus d)}$$

$$\boxed{F = ((a \oplus b) \oplus (c \oplus d)) \oplus 1}$$