(a)

The minimum values of X, Y and P are all 0

The maximum value of X = $1011101_2 = 64 + 16 + 8 + 4 + 1 = 93$

The maximum value of Y = $101101_2 = 32 + 8 + 4 + 1 = 45$

The maximum value of P = $(93)(45) = 4185$

A 12-bit unsigned number can represent values in the range [0, 4095], which is not large enough.

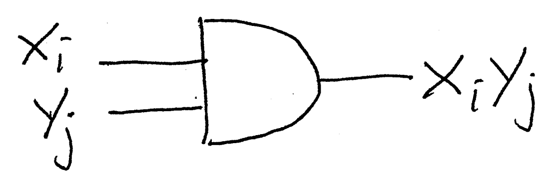
A 13-bit unsigned number can represent values in the range [0, 8191], which is large enough.

Therefore, the minimum number of bits needed to represent P is 13.

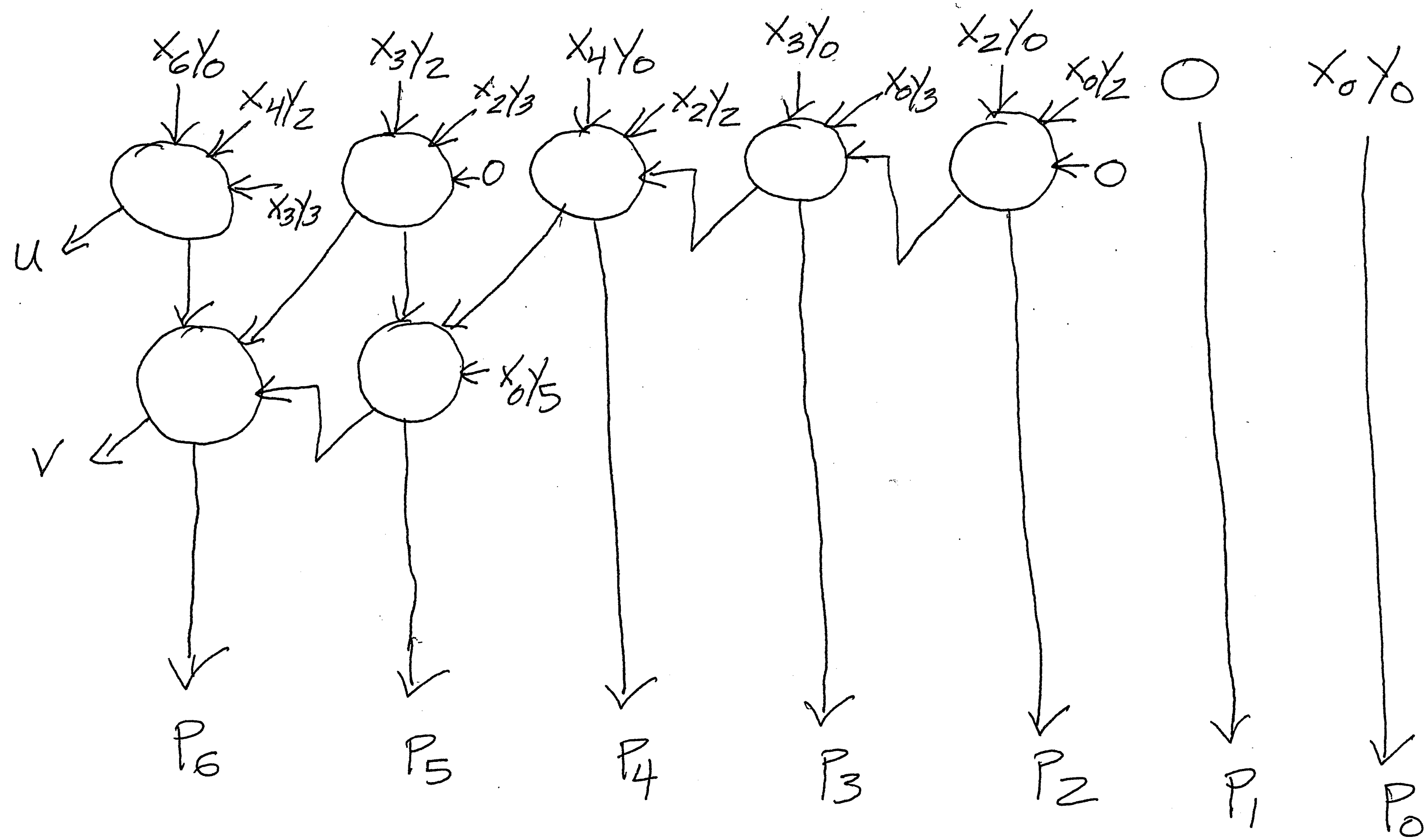
(b)

						X_6	0	X_4	X_3	X_2	0	X_0
							Y_5	0	Y_3	Y_2	0	Y_0
						X_6Y_0	0	X_4Y_0	X_3Y_0	X_2Y_0	0	X_0Y_0
				X_6Y_2	0	X_4Y_2	X_3Y_2	X_2Y_2	0	X_0Y_2		
			X_6Y_3	0	X_4Y_3	X_3Y_3	X_2Y_3	0	X_0Y_3			
	X_6Y_5	0	X_4Y_5	X_3Y_5	X_2Y_5	0	X_0Y_5					
P_{12}	P_{11}	P_{10}	P_9	P_8	P_7	P_6	P_5	P_4	P_3	P_2	P_1	P_0

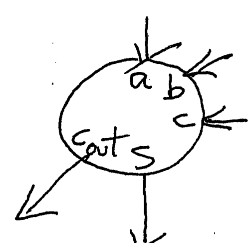
For each term X_iY_j in the above, include an AND gate as follows:



Circuit diagram - Part 1:

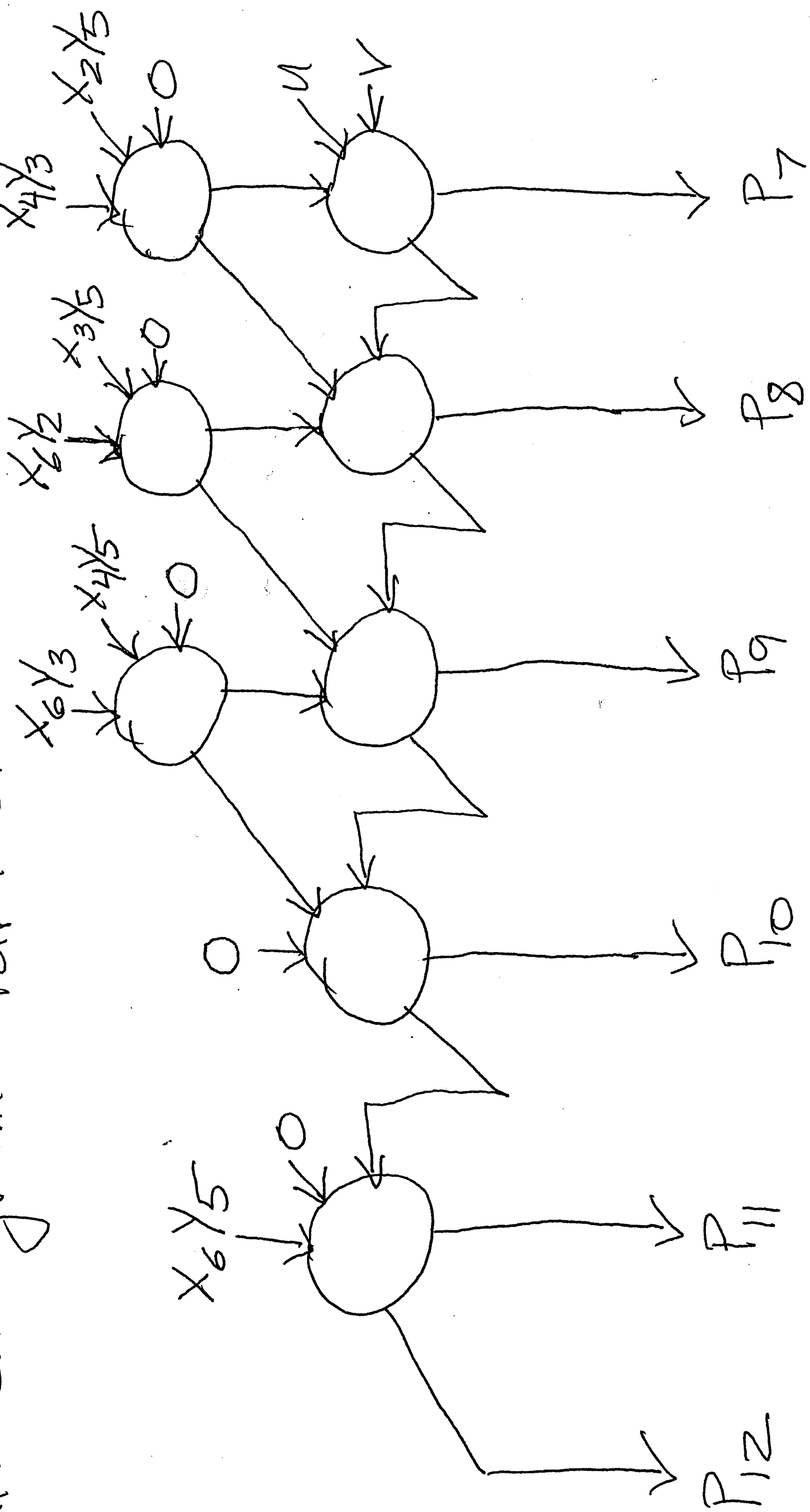


- Notation:
  A full adder is:



- Note: Assignment of signals to specific inputs of the full adders within a column is arbitrary.

Circuit diagram - Part 2:



(c)

The minimum value of Z = 10111000_2 = -128 + 32 +16 + 8 = -72

The maximum value of Z = 01111111_2 = 64 + 32 + 16 + 8 + 4 + 2 + 1 = 127

The minimum value of W = 0 + (32)(-72) = -2304

The maximum value of W = 4185 + (32)(127) = 8249

A 14-bit signed number can represent values in the range [-8192, 8191], which is not large enough.

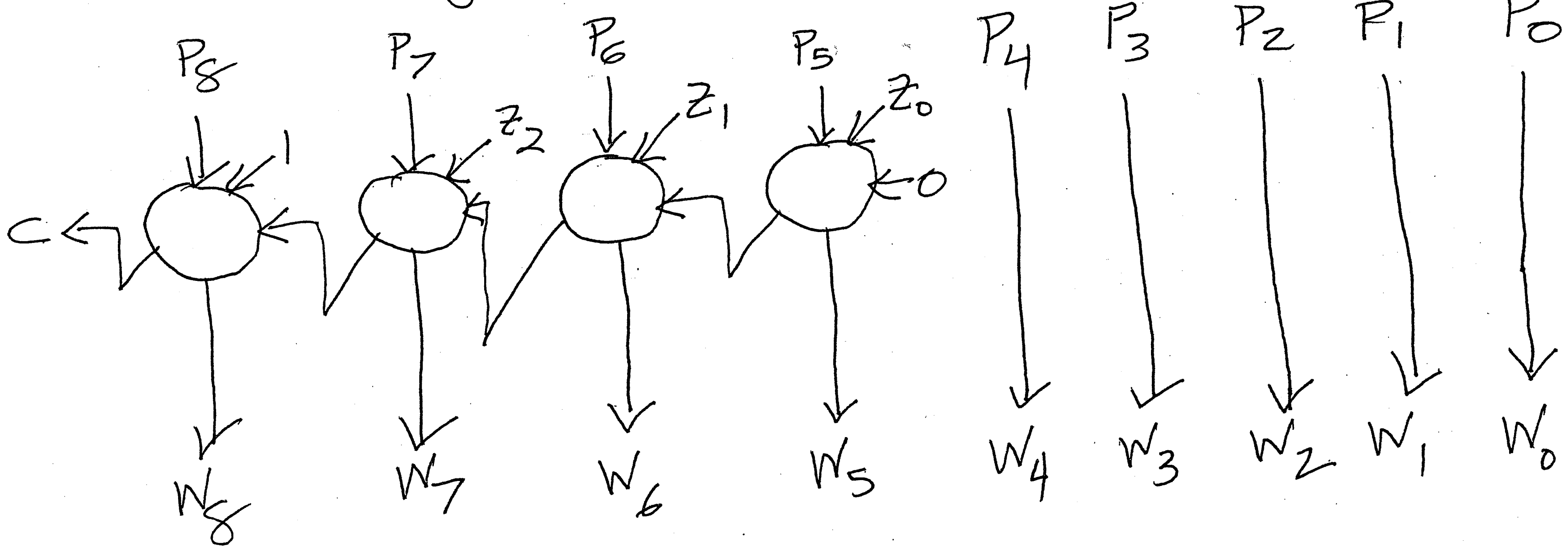
A 15-bit signed number can represent values in the range [-16384, 16383], which is large enough.

Therefore, the minimum number of bits need to represent W without any signed overflow is 15.

(d) sign-extend P and 32Z to 15-bits:

0	0	P_{12}	P_{11}	P_{10}	P_9	P_8	P_7	P_6	P_5	P_4	P_3	P_2	P_1	P_0
Z_7	Z_7	Z_7	Z_6	1	1	1	Z_2	Z_1	Z_0					
W_{14}	W_{13}	W_{12}	W_{11}	W_{10}	W_9	W_8	W_7	W_6	W_5	W_4	W_3	W_2	W_1	W_0

circuit diagram - part 1:



circuit diagram- Part 2: