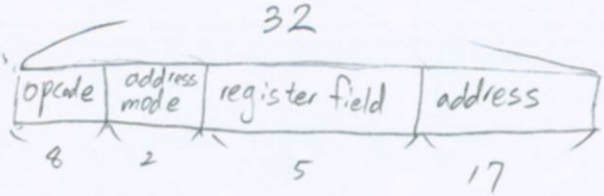
1.

(a)



∴ 256 opcodes as maximum.

(b) PC : 17 bits IR = 15 bits or 32 bits.
MAR : 17 bits AC = 32 bits
MDR : 32 bits

2.

(a) AND (There's already another operand in AC)

- Fetch
  i) MAR ← PC
  ii) MDR ← M[MAR], PC ← PC+1
  iii) IR ← MDR(opcode), MAR ← MDR(address)
- execute
  i) MDR ← M[MAR]
  ii) AC ← AC ∧ MDR

(b) ISZ

- Fetch
  i) MAR ← PC
  ii) MDR ← M[MAR], PC ← PC+1
  iii) IR ← MDR(opcode), MAR ← MDR(address)
- Execute
  i) MDR ← M[MAR]
  ii) AC ← MDR
  iii) AC ← AC+1, If(z=1) then PC ← PC+1

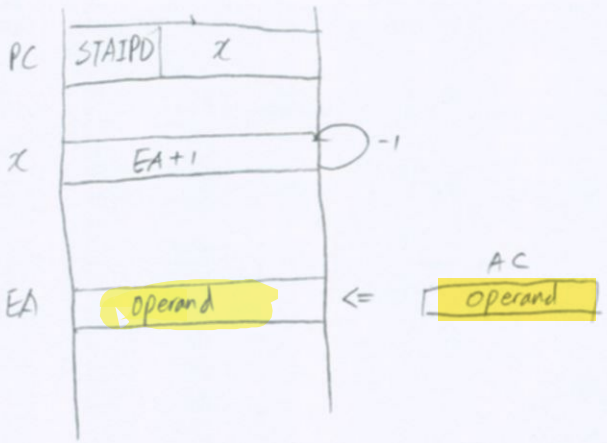
(c) DCA (There's already another operand in AC)

- Fetch
  i) MAR ← PC
  ii) MDR ← M[MAR], PC ← PC+1
  iii) IR ← MDR(opcode), MAR ← MDR(address)
- Eecute
  i) MDR ← AC
  ii) M[MAR] ← MDR, AC ← 0.

(d) JMS

- Fetch
  i) MAR ← PC
  ii) MDR ← M[MAR], PC ← PC+1
  iii) IR ← MDR(opcode), MAR ← MDR(address)
- Execute
  i) MDR ← PC
  ii) M[MAR] ← MDR, PC ← MAR
  iii) PC ← PC+1

3.



i) TEMP ← AC , MDR ← M[MAR]

ii) AC ← MDR

iii) AC ← AC-1 ,

iv) MDR ← AC

v) M[MAR] ← MDR , MAR ← MDR

vi) MDR ← TEMP

vii) M[MAR] ← MDR.

4.

i) MOV R1, R24

R0 01
R1 02
R2 1B
R3 07
R4 01
X 0106
Y 0102

SREG ------ 0 0 0 (N Z C)

ii) LD R4 Y+

R0 01
R1 05
R2 1B
R3 07
R4 EC
X 0106
Y 0103

SREG ------ 1 0 0 (N Z C)

0100 : 01
0101 : BE
0102 : 35
0103 : EC = 0b(1)110 1100)
↳ N Flag
0104 : 48
0105 : 2D
0106 : 04
0107 : 02

iii) LDI R4, 33

R0 01
R1 05
R2 1B
R3 07
R4 21
X 0106
Y 0102

SREG ------ 0 0 0 (N Z C)

iv) MUL R2, R3

R0 [redacted] BD
R1 [redacted] 00
R2 1B
R3 07
R4 01
X 0106
Y 0102

SREG ------ 0 0 1 (N Z C)

(∵ 1B × 07 = 00BD)
R1 R0

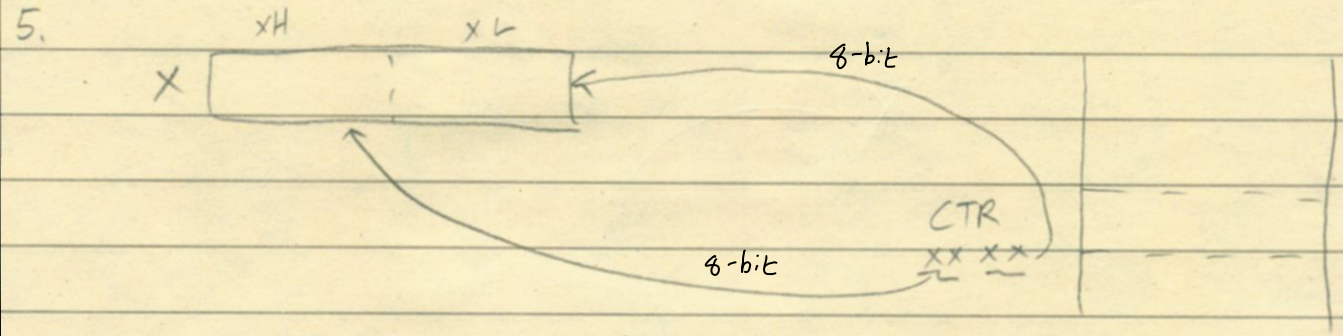
v) ROL R3

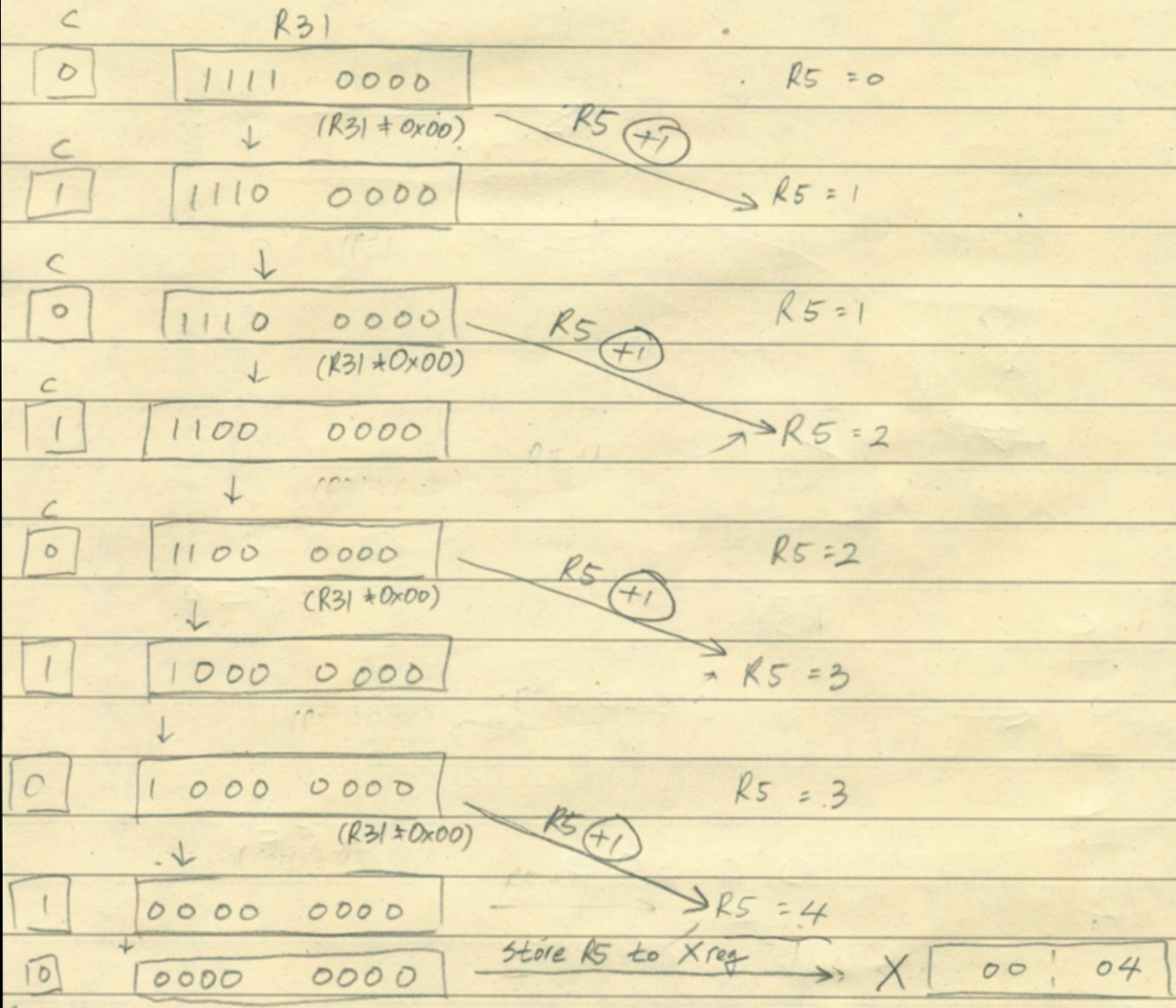
R0 01
R1 05
R2 1B
R3 0F
R4 01
X 0106
Y 0102

SREG ------ 0 0 0 (N Z C)

0000 0111 C=1 ∵ SREG = FF
⇓
C=0 0000 1111 ⇒ C=0 0F

5.





Program counts number of bit '1's in the R31 register.
By rotating bits to left and clearing carry, it keeps incrementing R5 until there is no bit '1' in R31 register. Thus, it iterates the number of bit '1' in register.
By storing R5 to X register, it changes the value of location CTR.

The value of location CTR = 0x0004.