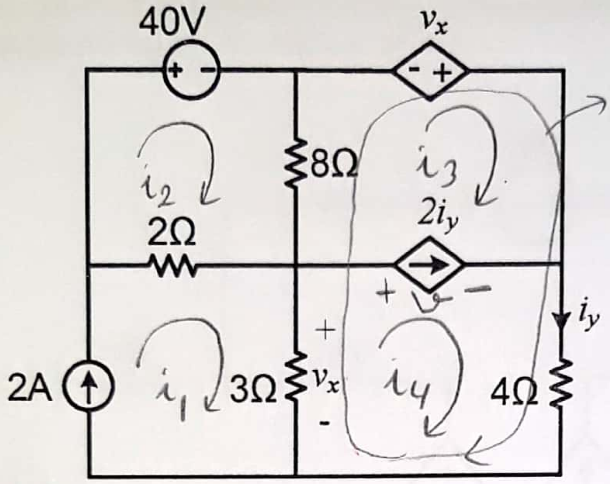
**Question 1 (30 pts)**

Find the power supplied by the current controlled current source by using mesh analysis.




super mesh

After finding mesh currents:

$v + 4(-2) + 3(-2-2) = 0$

$v = 20V$

$P_{CCCS} = v\,2i_y$
$= 20\,2(-2) = \underline{-80W}$ dissipated

$+80W$ supplied

$\boxed{i_1 = 2A}$

$i_4 - i_3 = 2i_y = 2i_4 \Rightarrow \boxed{i_4 = -i_3}$ (1)

KVL in loop 2

$40 + 8(i_2 - i_3) + 2(i_2 - 2) = 0$

$\boxed{10i_2 - 8i_3 = -36}$ (2)

KVL in super mesh

$-v_x + 4i_4 + 3(i_4 - 2) + 8(i_3 - i_2) = 0$

$v_x = 3(i_1 - i_4) = 3(2 - i_4)$

$-6 + 3i_4 + 7i_4 + 8i_3 - 8i_2 = 6 \leftarrow$ Substitute (1)

$\boxed{-2i_3 - 8i_2 = 12}$ (3)

$10i_2 - 8i_3 = -36$

$32i_2 + 8i_3 = -48$

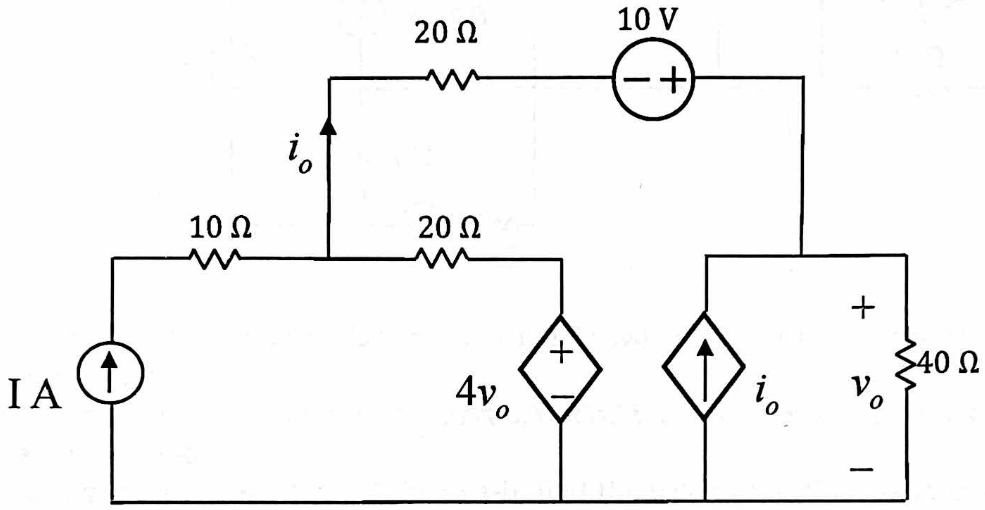
$42i_2 = -84 \Rightarrow \boxed{i_2 = -2A}$

$8i_3 = 10i_2 + 36$
$= +16$

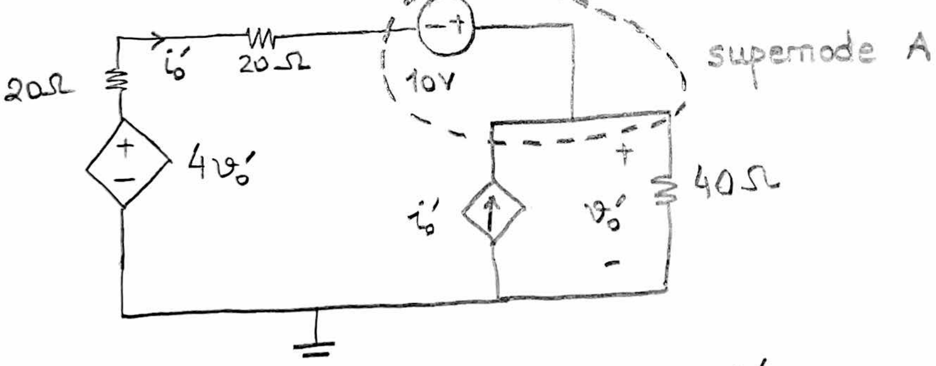
$\boxed{i_3 = +2A}$ $\boxed{i_4 = -2A}$

**Question 2 (30 pts)**

In the circuit shown below, the independent current source magnitude $I$ is not known. However, the output voltage $v_o$ across the 40 Ω resistor is measured as 3 V. Find the corresponding output voltage $v_o$ when the independent current source magnitude becomes $2I$ amperes.
Hint: Superposition principle might be helpful.




- Kill the independent current source, solve for $v_o'$:




KCL supernode A: $-i_o' - i_o' + \frac{v_o'}{40} = 0 \longrightarrow i_o' = \frac{v_o'}{80}$

constraint equation: $\frac{4v_o' - (v_o' - 10)}{20} = i_o' = \frac{v_o'}{80}$

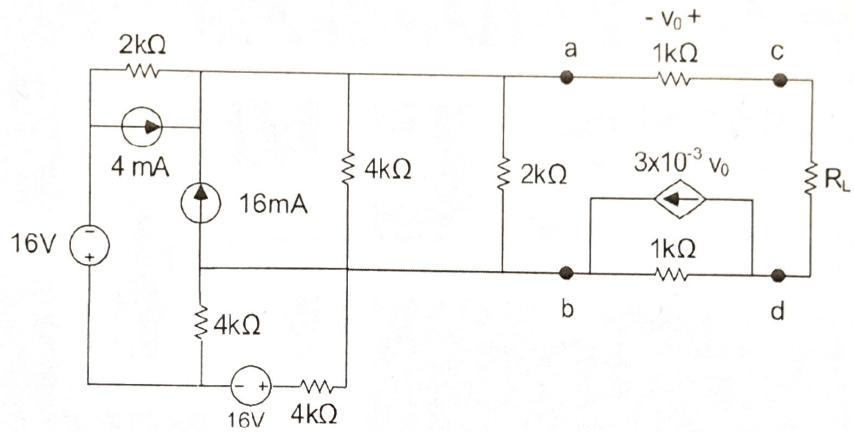
$\Rightarrow v_o' = -4$ V

$\Rightarrow$ contribution of I A in the output is 7 V.

$\Rightarrow$ if input were 2I A, output 14V

$\Rightarrow$ overall output $-4\text{V} + 14\text{V} = \boxed{10\text{ V}}$

**Question 3 (40 pts)**

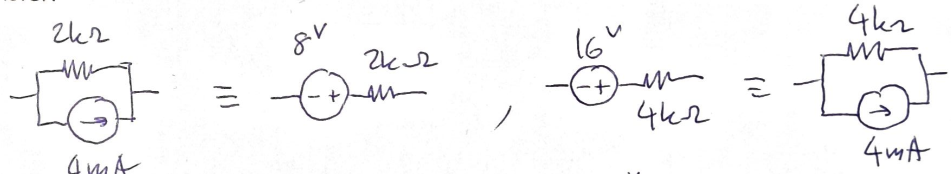



**a)** Use source transformations to find the Thevenin Equivalent of the circuit to the left of the terminals a-b.

**b)** Use the equivalent circuit from part-a, to find the next Thevenin equivalent circuit to the left of the terminal c-d.

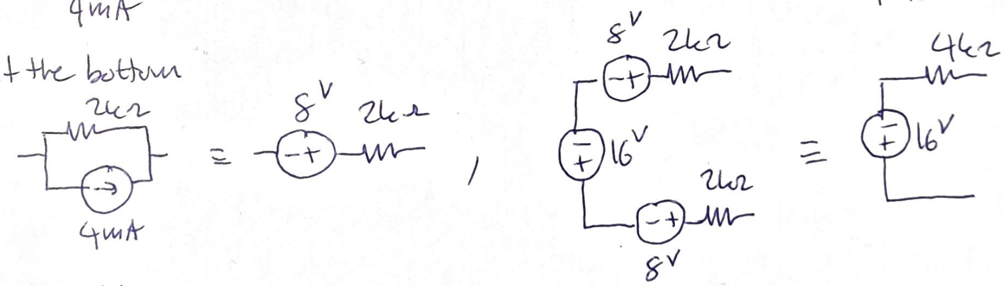
**c)** Using the equivalent circuit in part-b, find the value of $R_L$ that could ensure maximum power transfer.

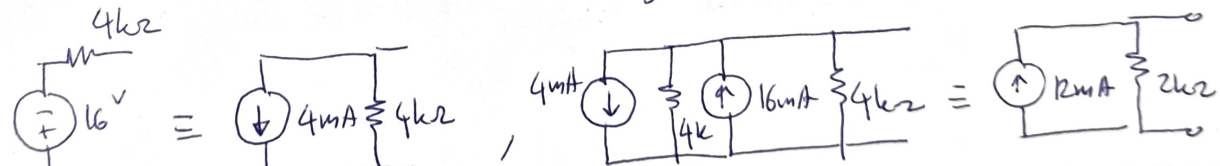
a)



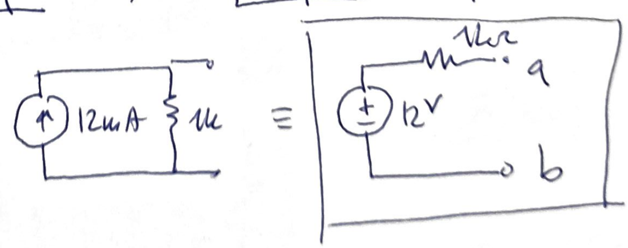

, $4K \| 4k = 2K$

at the bottom

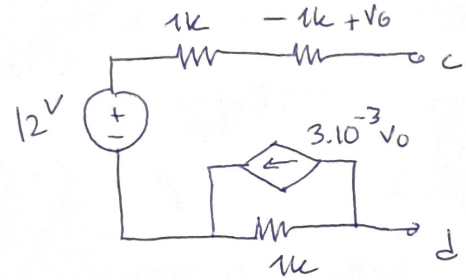



$2k\Omega \| 2k\Omega = 1k\Omega$



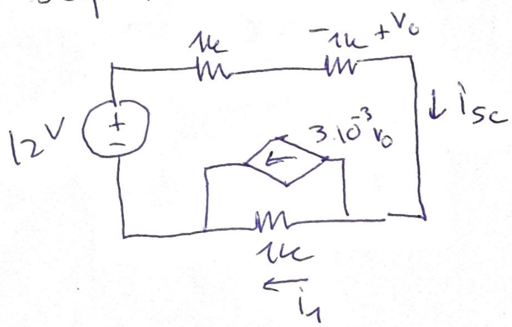
b) Based on a), we have




Step 1, Find the open-circuit voltage. Since $i=0$ on the top two resistors, $V_o = 0$ and hence

$V_{oc} = 12^V$

Step 2: Find $i_{sc}$




$V_o = -1\times10^3 i_{sc}$ (Ohm's law)

$i_1 = -3\times10^{-3} V_o + i_{sc}$ (KCL)

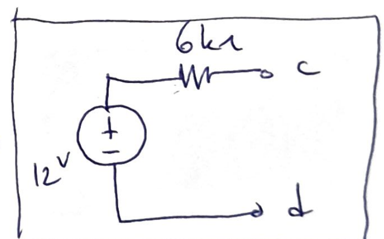
$= 3i_{sc} + i_{sc} = 4i_{sc}$

$12 - 2\times10^3 i_{sc} - 4\times10^3 i_{sc} = 0$ (KVL)

$\rightarrow i_{sc} = \dfrac{12}{6\times10^3} = 2mA$

$V_{th} = 12^V$

$R_{th} = \dfrac{V_{oc}}{i_{sc}} = \dfrac{12}{2\times10^{-3}} = 6k\Omega$ →




c) $R_L = R_{th}$ maximizes power, so $\boxed{R_L = 6k\Omega}$