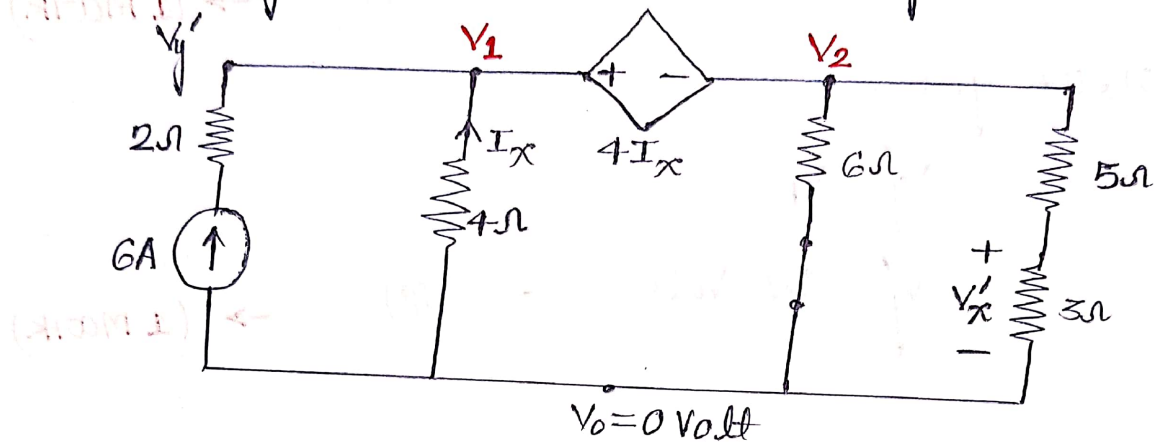


Mid Semester Exam Solution

Sol (1) ÷ By using Superposition theorem —  
 Case (I): Taking 6A current source only



Apply KCL at node  $V_1$  &  $V_2$ , we get —

$$\frac{V_1}{4} + \frac{V_2}{6} + \frac{V_2}{8} = 6$$

$$6V_1 + 7V_2 = 144 \quad \text{--- (1)}$$

$$V_1 - V_2 = 4I_x \quad \text{--- (2)}$$

$$\frac{V_1}{4} = -I_x \quad \text{--- (3)}$$

$$\frac{V_2}{8} = \frac{V'_x}{3} \quad \text{--- (4)}$$

$$V_1 = V'_y \quad \text{--- (5)}$$

→ (2.5 MARK)

By eq<sup>n</sup> (2) & eq<sup>n</sup> (3), we get —

$$V_1 - V_2 = -V_1$$

$$2V_1 = V_2 \quad \text{--- (6)}$$

By eq<sup>n</sup> (1) & eq<sup>n</sup> (6), we get —

$$V_1 = 7.2 \text{ Volt}$$

$$\therefore V_2 = 14.4 \text{ Volt}$$

(By eq<sup>n</sup> (6))

By eq<sup>n</sup>(4), we get —

$$V_x' = \frac{3}{8} V_2$$

$$V_x' = \frac{3}{8} (14.4)$$

$$V_x' = 5.4 \text{ Volt} \quad \text{--- (7)}$$

→ (1 Mark)

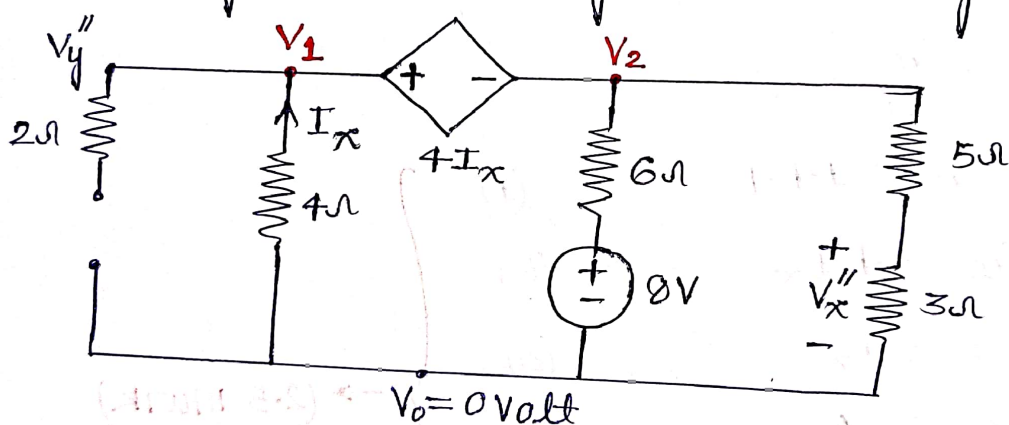
By eq<sup>n</sup>(5), we get —

$$V_y' = V_1$$

$$V_y' = 7.2 \text{ Volt} \quad \text{--- (8)}$$

→ (1 Mark)

Case(II): Taking 8 Volt Voltage Source only



Apply KCL at node V<sub>1</sub> & V<sub>2</sub>, we get —

$$\frac{V_1}{4} + \frac{V_2 - 8}{6} + \frac{V_2}{3} = 0$$

$$6V_1 + 7V_2 = 32 \quad \text{--- (a)}$$

$$V_1 - V_2 = 4I_x \quad \text{--- (b)}$$

$$\frac{V_1}{4} = -I_x \quad \text{--- (c)}$$

$$\frac{V_2}{3} = \frac{V_x''}{3} \quad \text{--- (d)}$$

$$V_y'' = V_1 \quad \text{--- (e)}$$

→ (2.5 Mark)

By eq<sup>n</sup> (b) & eq<sup>n</sup> (c), we get —  
 $2V_1 = V_2$  — (f)

By eq<sup>n</sup> (a) & eq<sup>n</sup> (f), we get —

$$V_1 = 1.6 \text{ Volt}$$

$$\therefore V_2 = 3.2 \text{ Volt}$$

(By eq<sup>n</sup> (f))

By eq<sup>n</sup> (d), we get —

$$V_x'' = \frac{3}{8} V_2$$

$$V_x'' = \frac{3}{8} (3.2)$$

$$V_x'' = 1.2 \text{ Volt} \quad \text{— (g)}$$

→ (1 Mark)

By eq<sup>n</sup> (e), we get —

$$V_y'' = V_1$$

$$V_y'' = 1.6 \text{ Volt} \quad \text{— (h)}$$

→ (1 Mark)

By Superposition Theorem,

$$\begin{aligned} V_x &= V_x' + V_x'' \\ &= 5.4 + 1.2 \\ &= 6.6 \text{ Volt} \end{aligned}$$

(By eq<sup>n</sup> (r) & eq<sup>n</sup> (g))

→ (0.5 Mark)

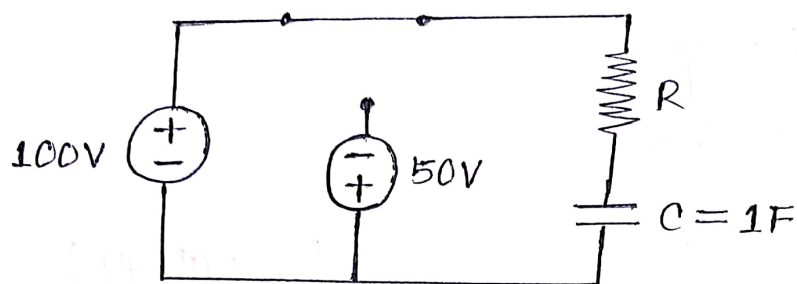
$$\begin{aligned} V_y &= V_y' + V_y'' \\ &= 7.2 + 1.6 \\ &= 8.8 \text{ Volt} \end{aligned}$$

(By eq<sup>n</sup> (s) & eq<sup>n</sup> (h))

→ (0.5 Mark)

Sol(2):

Case(I): At time  $t=0$  (Switch connected to Position-A)



Given that — Time constant ( $\tau$ ) = 2 sec

$$RC = 2$$

$$\therefore R = \left(\frac{2}{1}\right) = 2\Omega \rightarrow (1 \text{ Mark})$$

General eq<sup>n</sup> of RC circuit with source,

$$V_c(t) = [V_c(0^+) - V_c(\infty)] e^{-t/\tau} + V_c(\infty) \quad \text{--- (1)}$$

$$V_c(0^+) = V_c(0^-)$$

[given that  $V_c(0^-) = 0$  volt]

$$\therefore V_c(0^+) = 0 \text{ volt} \quad \text{--- (2)}$$

$\rightarrow (1 \text{ Mark})$

$$\therefore V_c(\infty) = 100 \text{ volt} \quad \text{--- (3)}$$

$\rightarrow (1 \text{ Mark})$

By eq<sup>n</sup> (1), eq<sup>n</sup> (2) & eq<sup>n</sup> (3), voltage response across capacitor,

$$V_c(t) = (0 - 100) e^{-t/2} + 100$$

$$V_c(t) = 100(1 - e^{-t/2}) \quad \text{--- (4)}$$

$\rightarrow (2.5 \text{ Mark})$

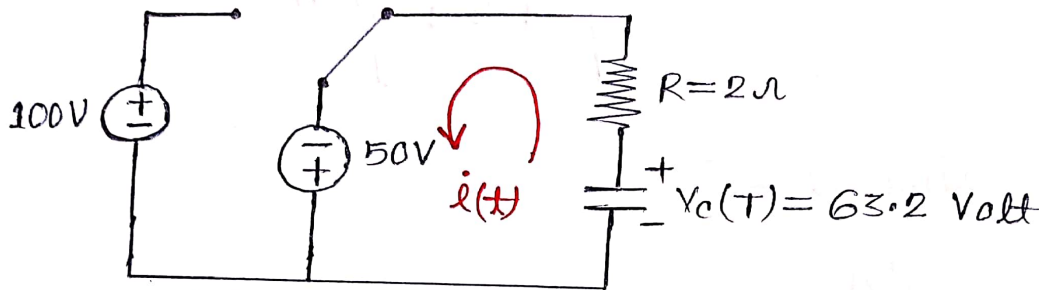
Case(II): At time  $t \geq \tau$  (Switch connected to position-B)

Voltage across capacitor (at  $t = T$ ),

$$V_c(T) = 100(1 - e^{-T/\tau})$$

$$V_c(T) \cong 63.2 \text{ Volt} \quad \text{--- (5)}$$

→ (0.5 Mark)



$$\therefore i(t=T) = \left( \frac{63.2 + 50}{2} \right) = 56.6 \text{ A} \quad \text{--- (6)}$$

→ (1 Mark)

$$\therefore i(t=\infty) = 0 \text{ A} \quad \text{--- (7)}$$

→ (1 Mark)

General eq<sup>n</sup> of current through capacitor,

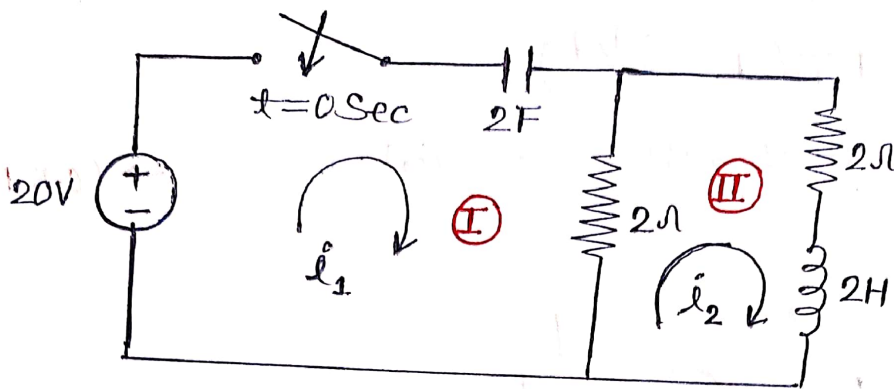
$$i(t) = [i(T) - i(\infty)] e^{-(t-T)/\tau} + i(\infty)$$

$$i(t) = (56.6 - 0) e^{-(t-T)/\tau} + 0$$

$$i(t) = 56.6 e^{-(t-2)/2}$$

→ (2 Mark)

Sol (3):



Case (I): At time  $t=0^-$

$$i_1(0^-) = 0 \text{ A}$$

$$i_2(0^-) = i_1(0^-) = 0 \text{ A}$$

$$V_C(0^-) = 0 \text{ volt}$$

→ (0.5 Mark)

→ (0.5 Mark)

Case (II): At time  $t=0^+$

$$i_1(0^+) = \frac{20}{2} = 10 \text{ A} \quad \text{--- (1)}$$

$$i_2(0^+) = i_2(0^-) = 0 \text{ A} \quad \text{--- (2)}$$

$$V_C(0^+) = V_C(0^-) = 0 \text{ volt} \quad \text{--- (3)}$$

→ (1 Mark)

→ (1 Mark)

→ (1 Mark)

Apply KVL in mesh-(II), we get -

$$2[i_2(t) - i_1(t)] + 2i_2(t) + 2 \cdot \frac{di_2(t)}{dt} = 0 \quad \text{--- (4)}$$

Put  $t=0^+$ , we get -

$$2(0 - 10) + 2 \times 0 + 2 \frac{di_2(0^+)}{dt} = 0$$

$$\therefore \frac{di_2(0^+)}{dt} = 10 \text{ A/sec}$$

--- (5) → (1.5 Mark)

Apply KVL in mesh-(I), we get -

$$-20 + \frac{1}{2} \int i_1(t) dt + 2[i_1(t) - i_2(t)] = 0 \quad \text{--- (6)}$$

Differentiate eq<sup>n</sup>(6), with respect to 't', we get -

$$0 + \frac{1}{2} \dot{i}_1(t) + 2 \left[ \frac{d \dot{i}_1(t)}{dt} - \frac{d \dot{i}_2(t)}{dt} \right] = 0 \quad \text{--- (7)}$$

Put  $t = 0^+$ , we get -

$$\frac{1}{2} \times 10 + 2 \left[ \frac{d \dot{i}_1(0^+)}{dt} - 10 \right] = 0$$

$$\therefore \frac{d \dot{i}_1(0^+)}{dt} = 7.5 \text{ A/sec} \quad \text{--- (8)} \rightarrow (1.5 \text{ Mark})$$

Differentiate eq<sup>n</sup>(4) with respect to 't', we get -

$$2 \left[ \frac{d \dot{i}_2(t)}{dt} - \frac{d \dot{i}_1(t)}{dt} \right] + 2 \frac{d \dot{i}_2(t)}{dt} + 2 \frac{d^2 \dot{i}_2(t)}{dt^2} = 0$$

Put  $t = 0^+$ , we get -

$$2 \left[ \frac{d \dot{i}_2(0^+)}{dt} - \frac{d \dot{i}_1(0^+)}{dt} \right] + 2 \frac{d \dot{i}_2(0^+)}{dt} + 2 \frac{d^2 \dot{i}_2(0^+)}{dt^2} = 0$$

$$2(10 - 7.5) + 2 \times 10 + 2 \frac{d^2 \dot{i}_2(0^+)}{dt^2} = 0$$

$$\therefore \frac{d^2 \dot{i}_2(0^+)}{dt^2} = -12.5 \text{ A/sec}^2 \quad \text{--- (9)} \rightarrow (1.5 \text{ Mark})$$

Differentiate eq<sup>n</sup>(7) with respect to 't', we get -

$$\frac{1}{2} \frac{d \dot{i}_1(t)}{dt} + 2 \left[ \frac{d^2 \dot{i}_1(t)}{dt^2} - \frac{d^2 \dot{i}_2(t)}{dt^2} \right] = 0$$

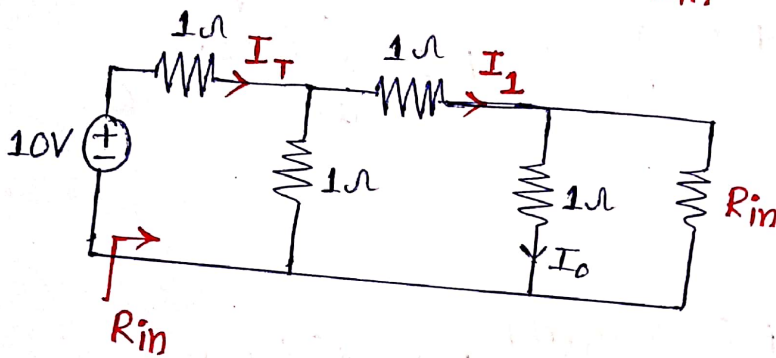
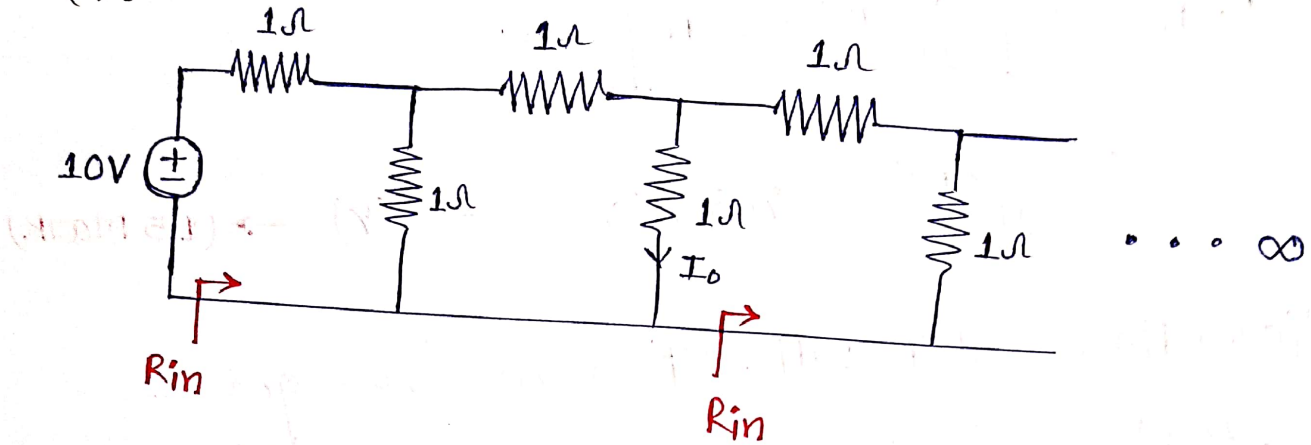
Put  $t = 0^+$ , we get -

$$\frac{1}{2} \times 7.5 + 2 \left[ \frac{d^2 \dot{i}_1(0^+)}{dt^2} + 12.5 \right] = 0$$

$$\therefore \frac{d^2 i_1(0^+)}{dt^2} = -14.375 \text{ A/sec}^2 \quad \text{--- (10)}$$

→ (1.5 Mark)

Sol (4)÷



$$\therefore R_{in} = \left( \frac{R_{in}}{1+R_{in}} + 1 \right) \parallel 1 + 1$$

$$R_{in} = \left( \frac{2R_{in}+1}{R_{in}+1} \right) \parallel 1 + 1$$

$$R_{in} = \frac{\left( \frac{2R_{in}+1}{R_{in}+1} \right)}{\left( \frac{2R_{in}+1}{R_{in}+1} \right) + 1} + 1$$

$$R_{in} = \left( \frac{2R_{in}+1}{3R_{in}+2} \right) + 1$$

$$R_{in}(3R_{in}+2) = 2R_{in}+1 + 3R_{in}+2$$

$$3R_{in}^2 + 2R_{in} = 5R_{in} + 3$$

$$3R_{in}^2 - 3R_{in} - 3 = 0$$

$$R_{in} = (1 \pm \sqrt{5})/2$$

$$R_{in} = 1.62 \, \Omega, \quad -0.62 \, \Omega$$

$$\therefore R_{in} = 1.62 \, \Omega$$

→ (2 Mark)

$$\therefore \text{Current, } I_T = \frac{10}{1.62} = 6.17 \, A$$

→ (1 Mark)

$$\begin{aligned} \therefore \text{Current, } I_1 &= \frac{1}{1 + (1 + 1 \parallel 1.62)} \times I_T \\ &= \frac{1}{1 + (1 + 0.62)} \times 6.17 \\ &= \frac{1}{2.62} \times 6.17 \\ &= 2.35 \, A \end{aligned}$$

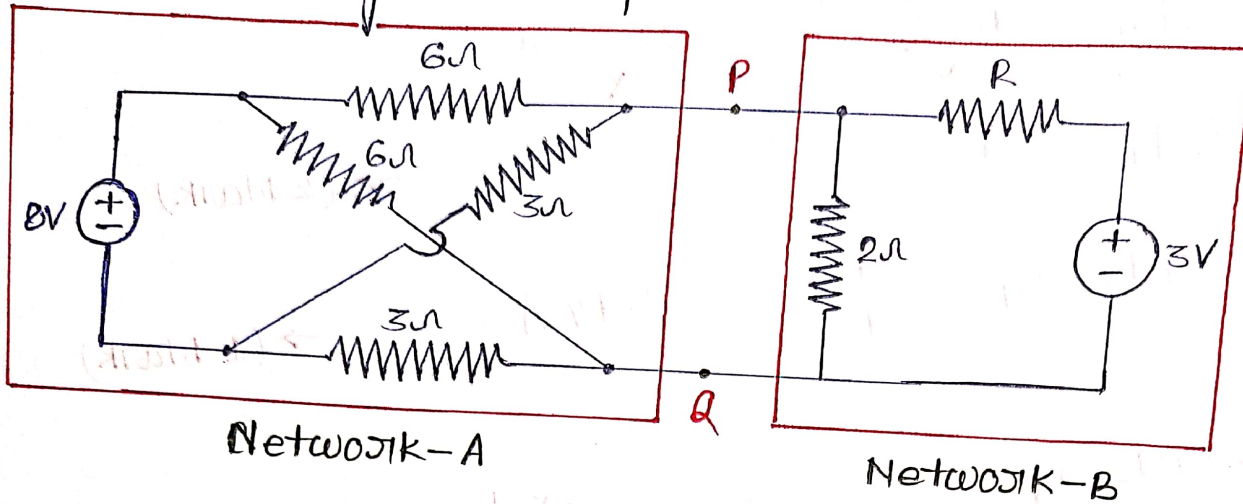
→ (1 Mark)

$$\begin{aligned} \therefore \text{Current, } I_o &= \left( \frac{1.62}{1 + 1.62} \right) \times I_1 \\ &= \frac{1.62}{2.62} \times 2.35 \\ &= 1.45 \, A \end{aligned}$$

→ (1 Mark)

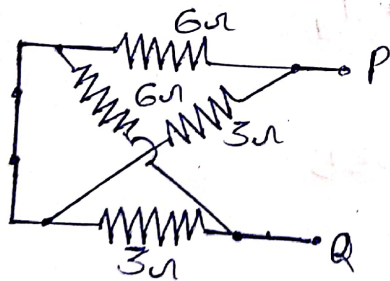
Sol(5)÷

At steady state capacitor behave as an open circuit



For maximum power transfer from Network-A (work as a source) to Network-B (work as a load), the value of equivalent resistance of Network-B is must be equal to source internal resistance (Thevenin resistance of Network-A).

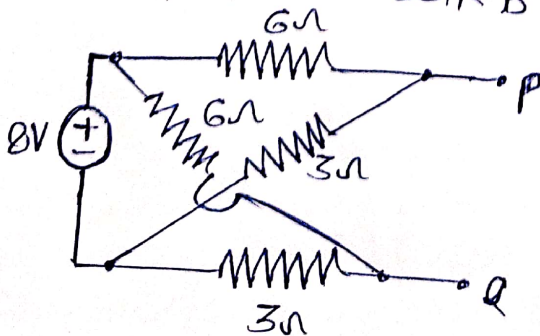
Step(I): For  $R_{th}$  of Network-A



$$\therefore R_{th} = 4\Omega$$

→ (2 Mark)

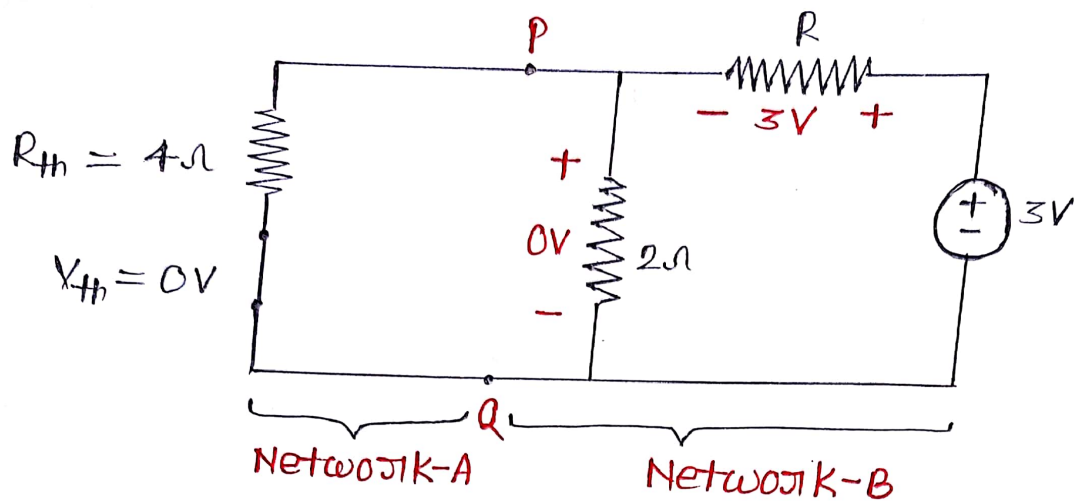
Step(II): For  $V_{th}$  of Network-B



$$\therefore V_{th} = (V_P - V_Q) = \left(\frac{3}{3+6}\right) 8 - \left(\frac{3}{3+6}\right) 8 = 0 \text{ Volt}$$

→ (2 Mark)

Now reduced circuit —



Here, Network-A can't be work as a source because  $V_{th} = 0$  volt. Hence we can not determine the value of 'R'.

→ (1 Mark)