(4) Circuit Theorems

Superposition Theorem:

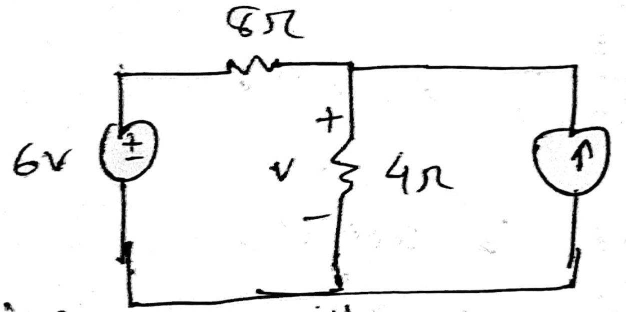
* সার্কিটে একাধিক current/voltage source থাকলে একটি source solve করার সময় অন্যগুলো অফ করে ফলগুলোর যোগফল হবে original circuit

কোন source অফ?

Voltage source off → using short circuit

Current " " → " open "

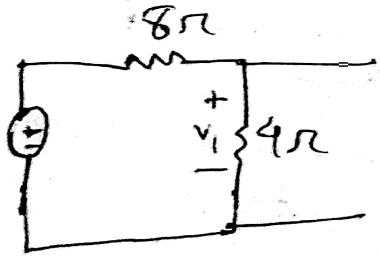
Ex – 4.3



(current source off)

Find v using superposition theorem

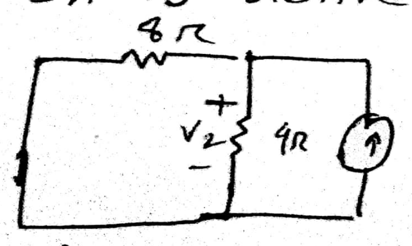
Ans: When 6V is active,



[series]
Voltage divider rule

$$v_1 = \frac{4}{8+4} \times 6 = 2V$$

When 3A is active



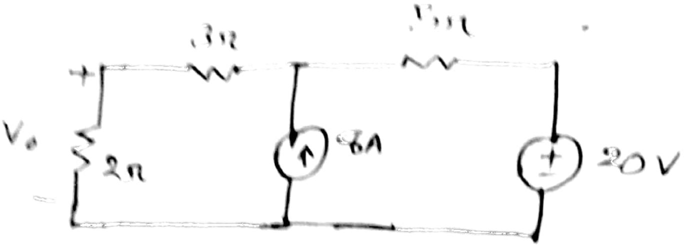
[Parallel]
current divider rule

$$i = \frac{1/4}{1/4 + 1/8} \times 3 = 2A$$

$V_2 = iR = 2 \times 4 = 8V$ [[illegible] resistance]

$\therefore V = V_1 + V_2$
$= 2 + 8 = 10V$

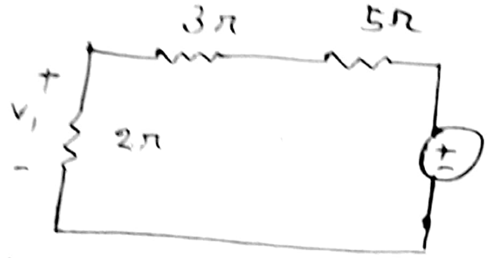
Practice Problem 4.3



Voltage/same

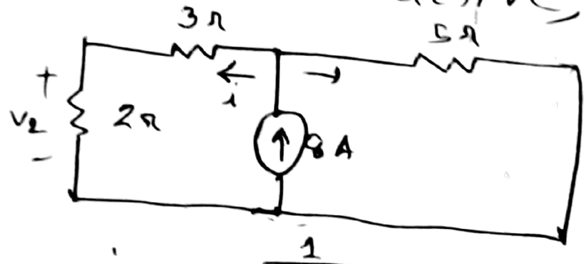
Find V_o

Ans. When 20V is active,



$$V_1 = \frac{2}{2+3+5} \times 20 = 4V$$

When 8A is active,

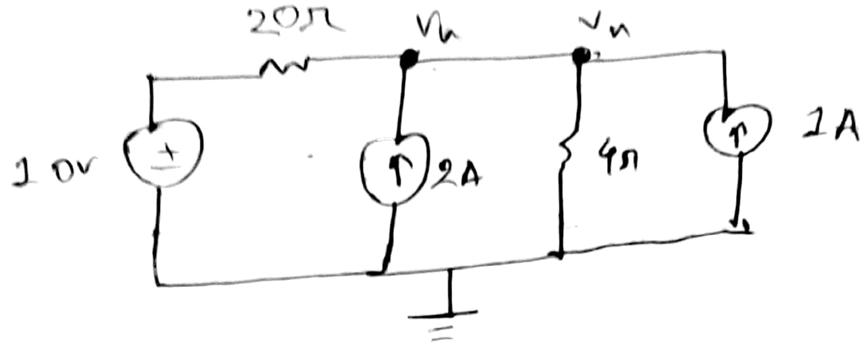


$$i = \frac{\frac{1}{2+3}}{\frac{1}{2+3} + \frac{1}{5}} \times 8 = 4A$$

$$V_2 = ir = 4 \times 2 = 8V$$

$$V_o = V_1 + V_2 = 4 + 8 = 12V$$ ← Superposition theorem.

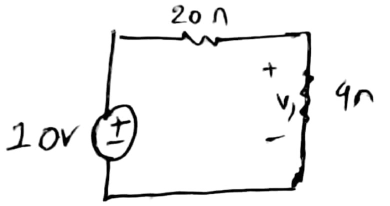
Practice Problem - 4.4 (modified)



$V_u \rightarrow$ ending point ground - 0

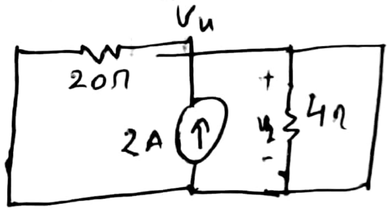
Find V_u

Ans: When 10V is active



$$\therefore V_1 = \frac{4}{20+4} \times 10 = 1.67V$$

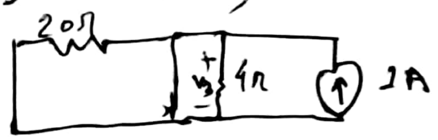
When 2A is active,



$$I_1 = \frac{\frac{1}{4}}{\frac{1}{20} + \frac{1}{4}} \times 2 = 1.67 A$$

$$V_2 = I_1 R = 1.67 \times 4 = 6.68 V$$

When 1A is active,



$$I_2 = \frac{\frac{1}{4}}{1/4 + 1/20} \times 1 = 0.833A$$

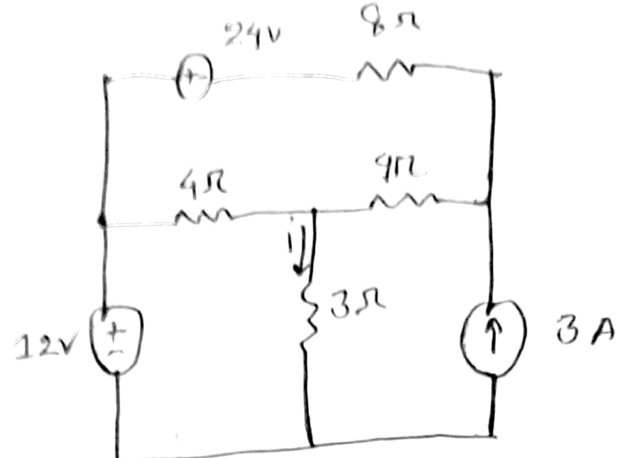
$$V_3 = I_2 R = 0.833 \times 4 = 3.332$$

$$V_u = V_1 + V_2 + V_3 = 1.67 + 6.68 + 3.332 = 11.682V$$

Ans

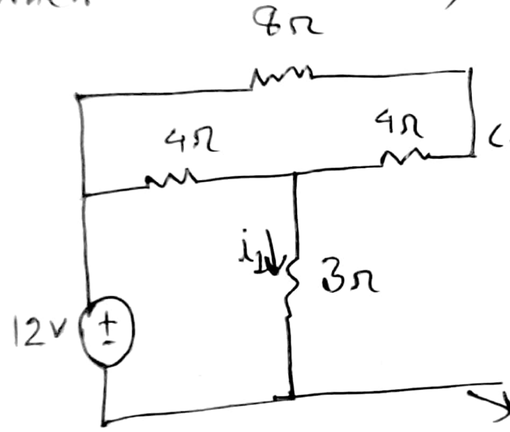
(4) Release (Circuit Theorems)
(2nd Part)

Ex-4.5



Find i using superposition theorem

Ans. When 12V is active,



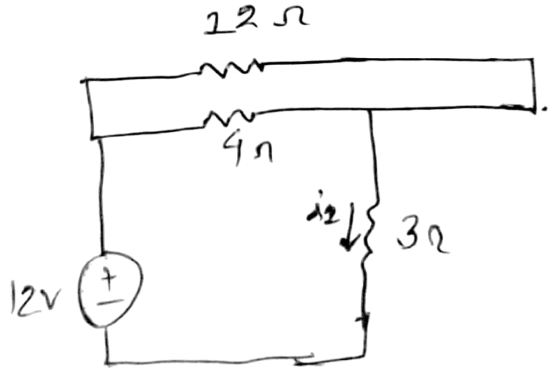
← short circuit for V

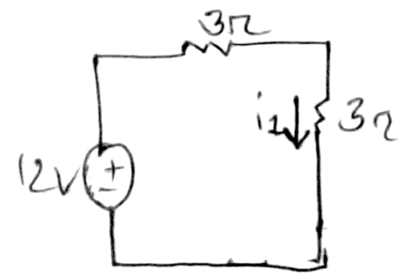
যে পাশেই 8Ω কেবল সে পাশেরই 4Ω শুধু

← open circuit for A

No need this wire

8+4 = series,
12∥4,

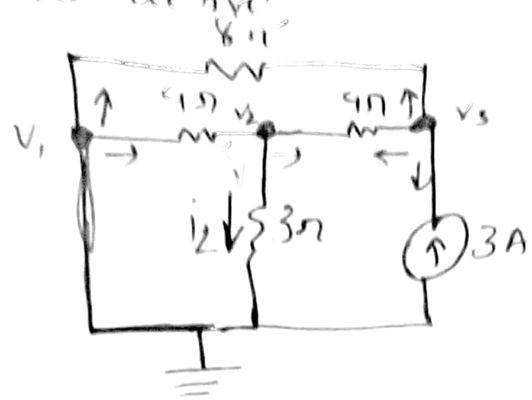




← একে বের করতে হবে তাই একে হাত দেয়া যাবেনা

$i_1 = V/R = 12/6 = 2A$ [Ohm's Law]

When 3A is active



$V_1 = 0V$ [কেন?] source cut

Node 2:

$$\frac{V_2 - 0}{4} + \frac{V_2 - 0}{3} + \frac{V_2 - V_3}{4} = 0$$

$$\left(1/4 + 1/4 + 1/3\right)V_2 - 1/4\, V_3 = 0 \qquad \text{— (i)}$$

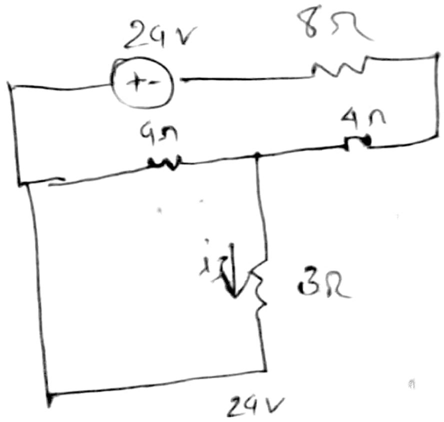
Node 3:

$$\frac{V_3 - V_2}{4} - 3 + \frac{V_3 - V_1(0)}{8} = 0$$

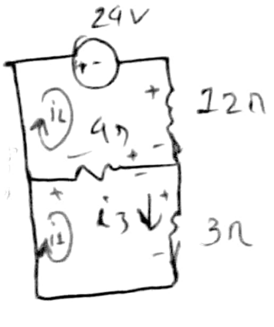
$$-1/4\, V_2 + \left(1/4 + 1/8\right)V_3 = 3 \qquad \text{— (ii)}$$

$V_2 = 3V$ $\quad$ $V_3 = 10V$

$$i_2 = \frac{V}{R} = \frac{3}{3} = 1A$$



8 + 4
= 12 Ω



Mesh-1:

$$-4(i_1 - i_2) - 3i_1 = 0$$

$$-7i_1 + 4i_2 = 0 \text{ ——— (i)}$$

Mesh-2:

$$-24 - 12i_2 - 4(i_2 - i_1) = 0$$

$$4i_1 - 16i_2 = 24 \text{ ——— (ii)}$$

$$i_1 = -1A$$

$$i_2 = -1.75$$

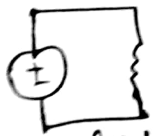
$$i_3 = i_1 = -1A$$

$$i = i_1 + i_2 + i_3$$

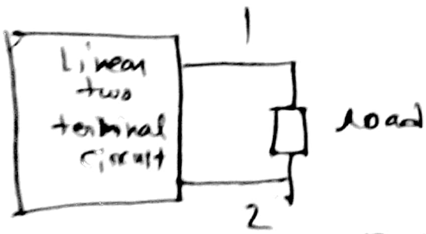
$$= 2 + 1 + (-1) = 2A$$

Thevenin's Theorem

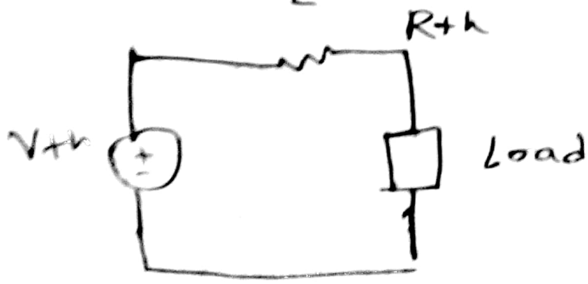
Simplest Circuit: 1 source, 1 resistance



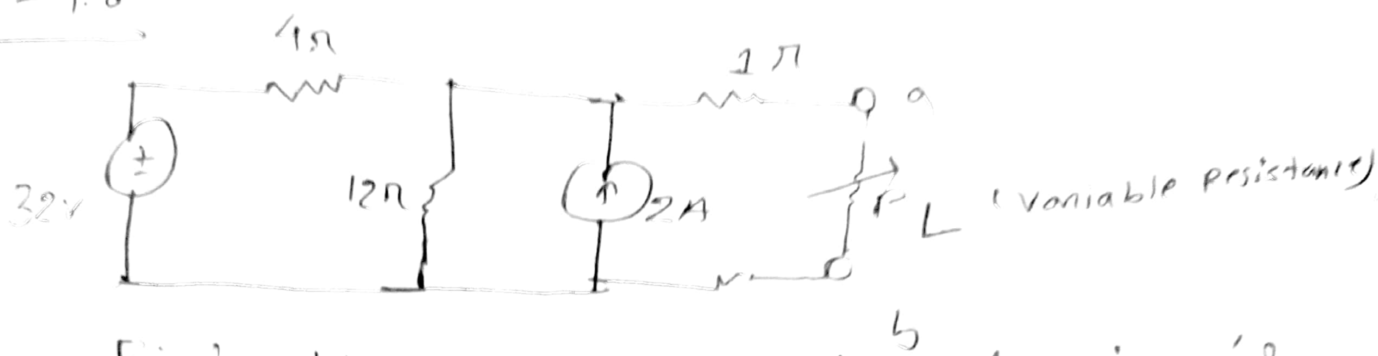
যেকোনো complicated circuit কে simplest circuit এ রূপান্তর করা যায়।



th = thevenin



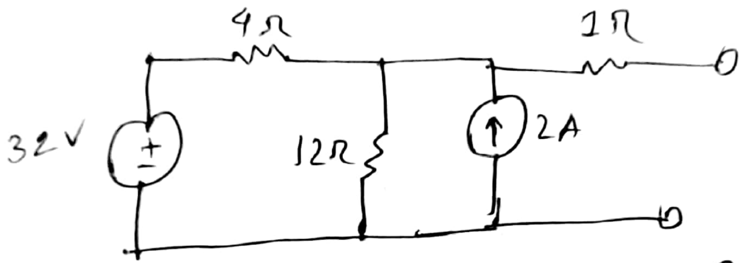
Ex - 4.8



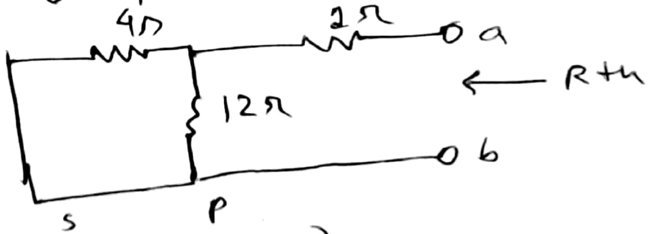
Find the Thevenins equivalent circuit

Ans:

Step 1: Open the load terminal



Step 2: Turn off all sources & calculate R_{th} from the load terminal.

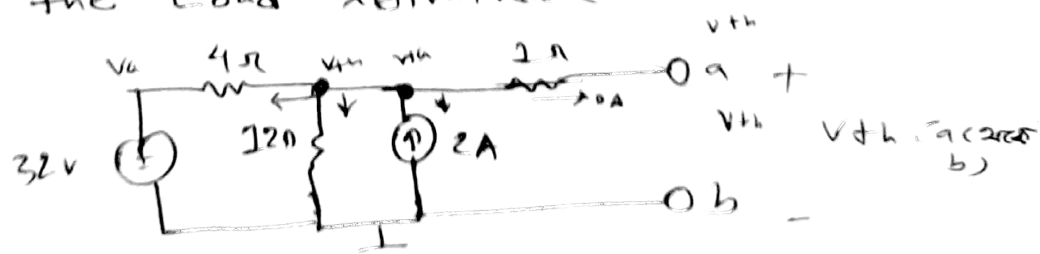


$R_{th} = 1 + (4 \parallel 12)$

$= 4\Omega$

Step 3: Return all sources and find V_{th} from the Load terminal.

best apply mesh analysis



$V_{1\Omega} = 0 \times 1\Omega = 0V$ (acting like a short circuit)

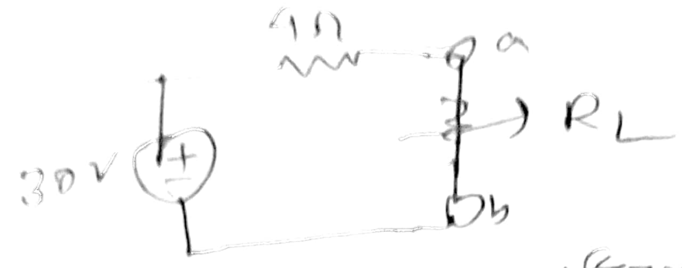
$V_a = 32V$

$\frac{V_{th} - 32}{4} + \frac{V_{th}}{12} - 2 = 0$

$(1/4 + 1/12)V_{th} = 10$

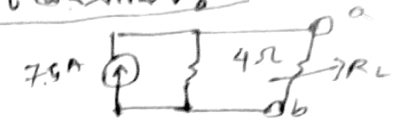
$V_{th} = 30V$

Step 4: Draw the Thevenin equivalent circuit using V_{th}, R_{th} and load.



Ans.

বিকল্পভাবে:



$R_N = 4\Omega$

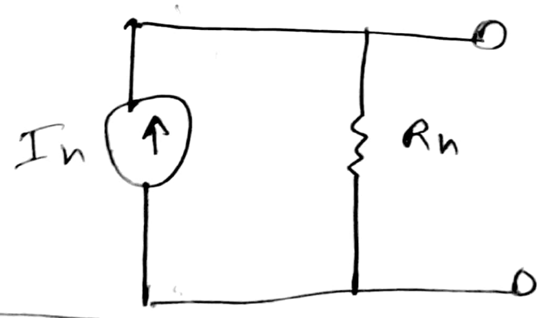
$I_N = \frac{V_{th}}{R_{th}} = \frac{30}{4} = 7.5A$

Norton's Theorem

যেকোনো complicated circuit কে একটি current source এবং একটি parallel resistance দিয়ে প্রকাশ করা যায়।

Thevinin → voltage source, current এর series Resistance

Norton → current source, current এর parallel Resistance



$\boxed{R_n = R_{th}}$

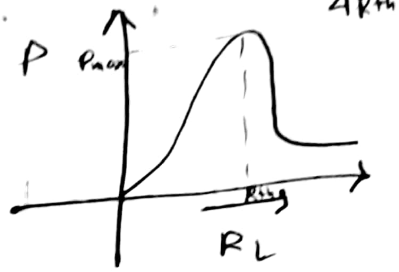
$I_n = \frac{V_{th}}{R_{th}}$

Maximum Power Transfer Theorem: R_L এর কোনো (Variable resistance) এর মান পরিবর্তন করে maximum power সরবরাহ করে। (Source থেকে সর্বোচ্চ Power R_L পাবে)

Source থেকে load-এ maximum power transfer হবে যখন $R_L = R_{th}$ হবে।

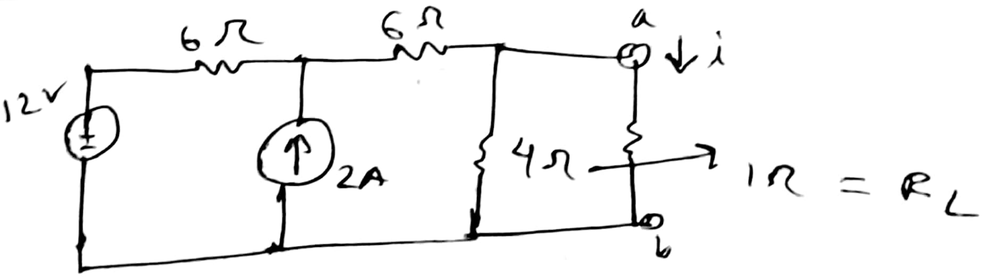
Q: Find the value of R_L for which maximum power transfer occurs?

$$\boxed{P_{max} = \frac{V_{th}^2}{4R_{th}}}$$



$R_L = 4\Omega$, $P_{max} = \frac{V_{th}^2}{4R_{th}} = \frac{30^2}{4 \times 4} = \cancel{1.875}$ 56.25 W

Practice Problem 4.8



a) Find Thevenin's Equivalent Circuit.

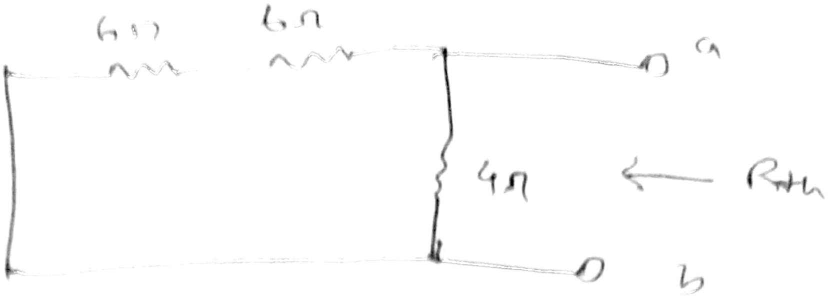
b) " Norton's " "

c) " the value of R_L for maximum power transfer

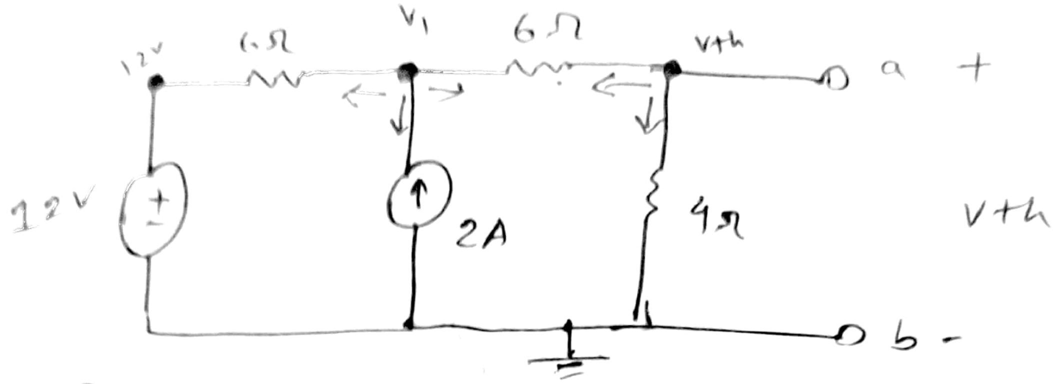
d) Find the value of maximum power

e) Find the value of i for $R_L = 1\Omega$

a)



$R_{th} = (6+6) \| 4 = 3\Omega$



[এটি Node (a) এর Voltage Vth বলা হবে এবং নেগেটিভ (b) গ্রাউন্ড]

V_1 এর জন্য,

$$\frac{V_1 - 12}{6} + \frac{V_1 - V_{th}}{6} - 2 = 0$$

$$\left(\frac{1}{6} + \frac{1}{6}\right) V_1 - \frac{1}{6} V_{th} = 4 \quad \text{—— (i)}$$

V_{th} এর জন্য,

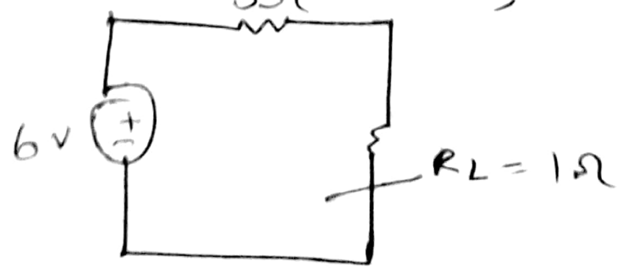
$$\frac{V_{th} - V_1}{6} + \frac{V_{th}}{4} = 0$$

$$-1/6\, V_1 + (1/6 + 1/4)\, V_{th} = 0 \quad \text{—— (ii)}$$

$V_1 = 15v$

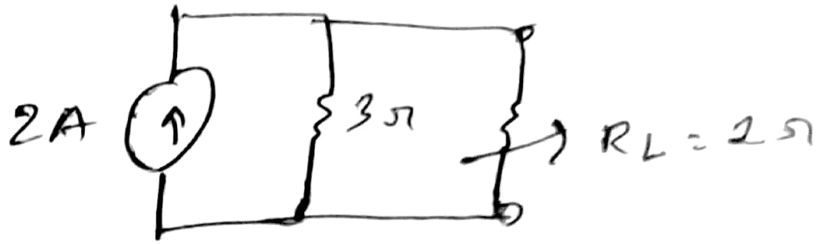
$V_{th} = 6v$

Thevenin's Equivalent circuit,



b) $R_N = R_{th} = 3\Omega$

$I_N = \frac{V_{th}}{R_{th}} = \frac{6}{3} = 2A$



c) $R_L = R_{th} = 3\Omega$

d) $P_{max} = \frac{V_{th}^2}{4R_{th}} = \frac{6^2}{4 \times 3} = \frac{36}{12} = 3W$

e) From Thevenin's Equivalent Circuit,

Ohm's law, $i = \frac{V}{R_{eq}} = \frac{6}{3+1} = \frac{6}{4} = 1.5A$