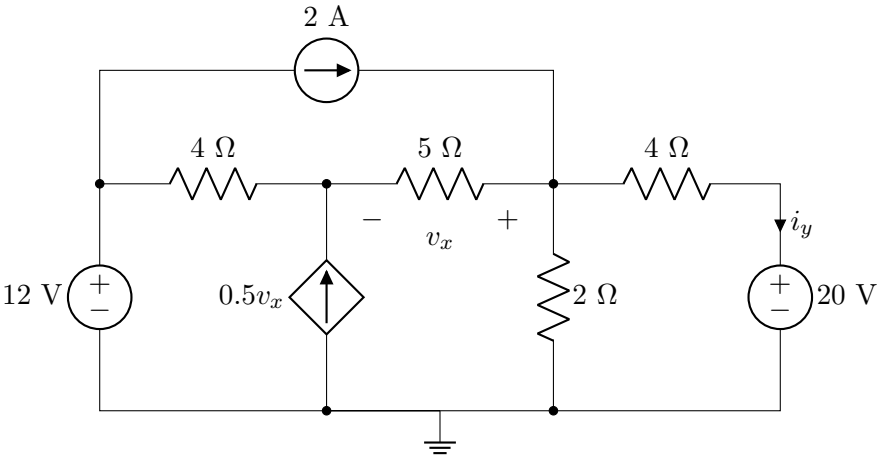
Question 1 of 3 *[20 marks]*

Set: 1

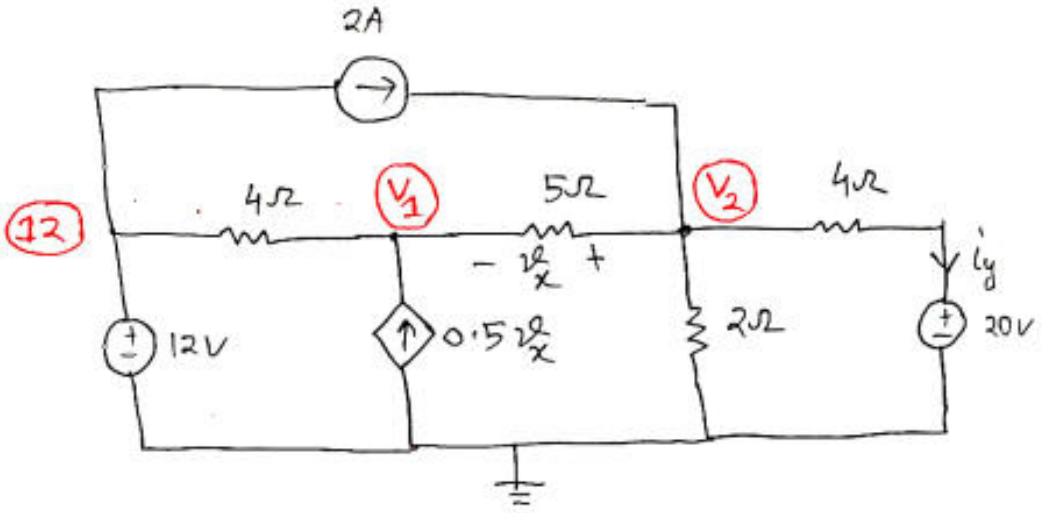


- **Apply Nodal/Mesh Analysis** to **identify** the values of the node voltages/mesh currents. *(Equations must be highlighted using boxes).*
  (18 marks) [CO2, CO4]

- **What** is the value of v_x and i_y? (with appropriate ± sign)?
  (2 marks) [CO1, CO2]

Set 1

Q1 Nodal



KCL at node 1,

$$0.5v_x = \frac{V_1 - 12}{4} + \frac{V_1 - V_2}{5}$$

$$\Rightarrow 0.5(V_2 - V_1) = \frac{V_1}{4} - 3 + \frac{V_1}{5} - \frac{V_2}{5} \quad [v_x = V_2 - V_1]$$

$$\Rightarrow 10V_2 - 10V_1 = 5V_1 - 60 + 4V_1 - 4V_2$$

$$\Rightarrow \boxed{19V_1 - 14V_2 = 60} \quad \text{(i)}$$

KCL at node 2,

$$2 = \frac{V_2 - V_1}{5} + \frac{V_2}{2} + \frac{V_2 - 20}{4}$$

$$\Rightarrow 40 = 4V_2 - 4V_1 + 10V_2 + 5V_2 - 100$$

$$\Rightarrow \boxed{4V_1 - 19V_2 = -140} \quad \text{(ii)}$$

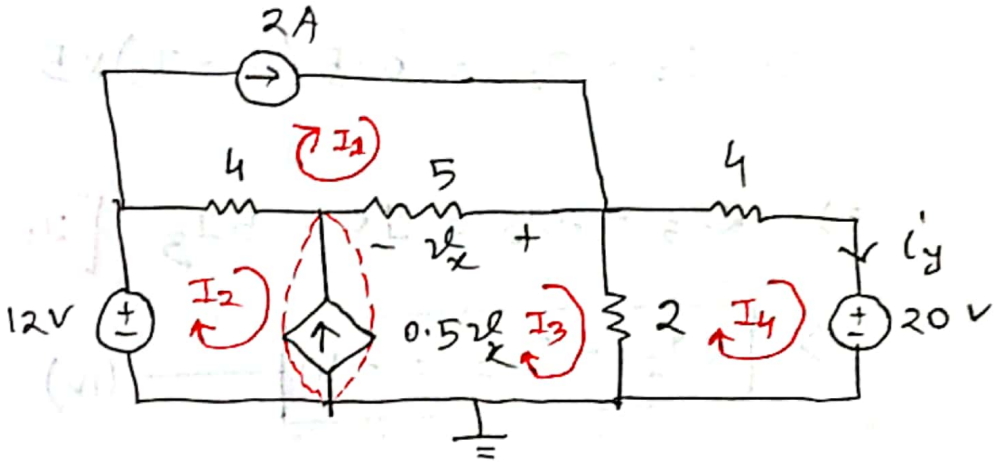
Solving (i) & (ii) ... ...

$$V_1 = 10.16\ (V) \quad ; \quad V_2 = 9.51\ (V)$$

$$V_x = V_2 - V_1 = -0.65\ (V)$$

$$i_y = \frac{V_2 - 20}{4} = -2.62\ (A)$$

Mesh



$$\boxed{I_1 = 2} \quad \text{——(i)}$$

KVL at loops 2, & 3 (supermesh),

$$-12 + 4(I_2 - I_1) + 5(I_3 - I_1) + 2(I_3 - I_4) = 0$$

$$\Rightarrow -12 + 4I_2 - 8 + 5I_3 - 10 + 2I_3 - 2I_4 = 0 \quad [I_1 = 2]$$

$$\Rightarrow \boxed{4I_2 + 7I_3 - 2I_4 = 30} \quad \text{——(ii)}$$

KVL at loop 3,

$$2(I_4 - I_3) + 4I_4 + 20 = 0$$

$$\Rightarrow \boxed{2I_3 - 6I_4 = 20} \quad \text{(iii)}$$

At the supermesh,

$$I_3 - I_2 = 0.5\, v_x$$

$$\Rightarrow I_3 - I_2 = 0.5(I_1 - I_3) \times 5 \quad [v_x = 5(I_1 - I_3)]$$

$$\Rightarrow 2I_3 - 2I_2 = 10 - 5I_3 \quad [I_1 = 2]$$

$$\Rightarrow \boxed{2I_2 - 7I_3 = -10} \quad \text{(iv)}$$

Solving (ii), (iii), & (iv) ... ...

$$I_2 = 2.46 \text{ (A)}$$

$$I_3 = 2.13 \text{ (A)}$$

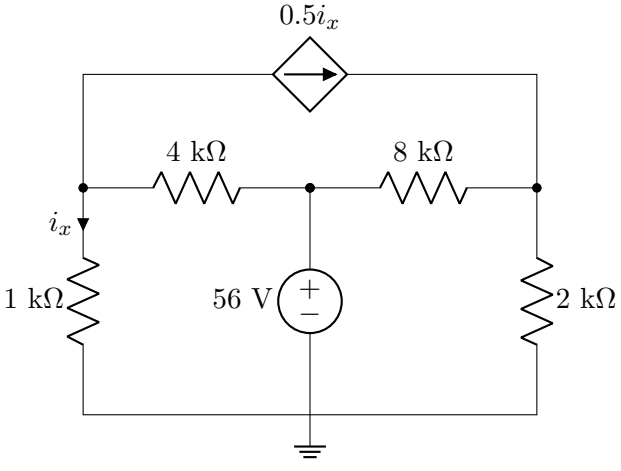
$$I_4 = -2.62 \text{ (A)}$$

$$v_x = 5(I_1 - I_3) = -0.65 \text{ (V)}$$

$$i_y = I_4 = -2.62 \text{ (A)}$$

Question 2 of 3 *[20 marks]*

Set: 1

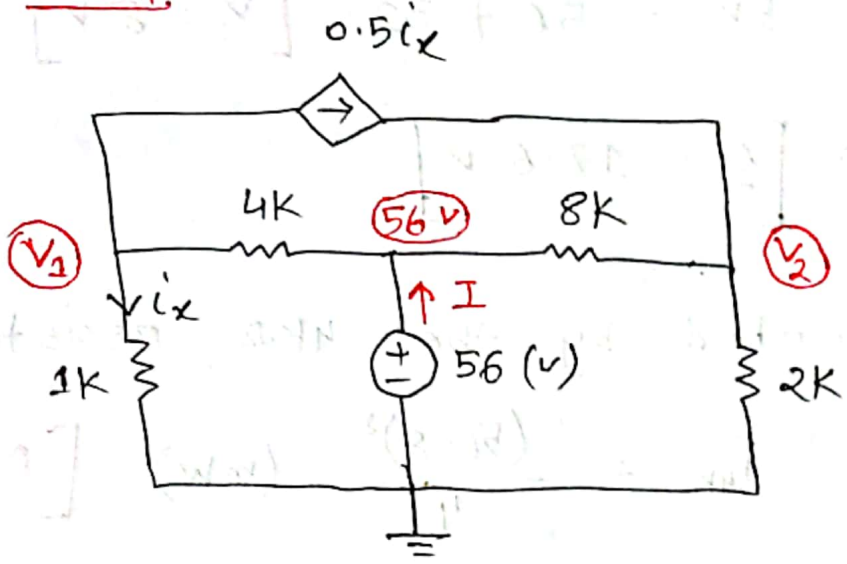


- **Apply Nodal/Mesh Analysis** to **identify** the values of the node voltages/mesh currents. *(Equations must be highlighted using boxes).*
  (14 marks) [CO2, CO4]

- **What** is the power absorbed by the 4 kΩ resistor? (with appropriate ± sign)?
  (2 marks) [CO1, CO2]

- **What** is the power supplied/absorbed by the voltage source? (with appropriate ± sign)?
  (4 marks) [CO1, CO2]

Q2 Nodal.



KCL at node 1,

$$0.5\,i_x + \frac{V_1}{1} + \frac{V_1 - 56}{4} = 0$$

$$\Rightarrow 0.5\,\frac{V_1}{1} + \frac{V_1}{1} + \frac{V_1 - 56}{4} = 0 \qquad \left[i_x = \frac{V_1}{1}\right]$$

$$\Rightarrow \quad 6V_1 + V_1 - 56 = 0$$

$$\Rightarrow \quad 7V_1 = 56$$

$$\Rightarrow \quad \boxed{V_1 = 8\,(V)}$$

KCL at node 2,

$$0.5\,i_x = \frac{V_2}{2} + \frac{V_2 - 56}{8}$$

$$\Rightarrow \quad 0.5\,\frac{V_1}{1} = \frac{V_2}{2} + \frac{V_2}{8} - 7 \qquad \left[i_x = \frac{V_1}{1}\right]$$

$$\Rightarrow \quad 4V_1 = 4V_2 + V_2 - 56$$

$$\Rightarrow \quad 5V_2 = 56 + 32 \qquad [V_1 = 8\,V]$$

$$\Rightarrow \quad \boxed{V_2 = 17.6\ V}$$

Power absorbed by the 4kΩ resistor,

$$P_{4K} = \frac{(56-8)^2}{4} \ (mW) \qquad \left[P = \frac{V^2}{R}\right]$$

$$\boxed{P_{4K} = 576\ mW}$$

Let the 56 V source is supplying current I as shown in the figure above,

KCL at the middle node,

$$I = \frac{56 - V_1}{4} + \frac{56 - V_2}{8}$$

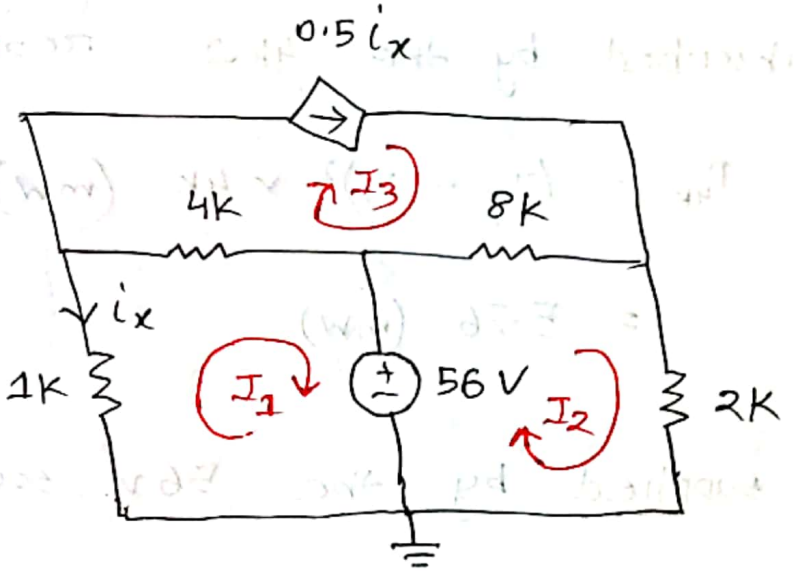
$$\Rightarrow \quad I = 16.8\ (mA) \qquad [V_1 = 8V \ ; \ V_2 = 17.6\ V]$$

So, power supplied by the voltage source

$$= -\ 56 \times 16.8\ (mW)$$

$$= -940.8\ (mW)$$

Mesh



KVL at mesh 1,

$$I_1 + 4(I_1 - I_3) + 56 = 0$$

$$\Rightarrow \boxed{5I_1 - 4I_3 = -56} \quad \text{(i)}$$

KVL at mesh 2,

$$-56 + 8(I_2 - I_3) + 2I_2 = 0$$

$$\Rightarrow \boxed{10I_2 - 8I_3 = 56} \quad \text{(ii)}$$

At mesh 3,

$$I_3 = 0.5 i_x = -0.5 I_1 \quad [i_x = -I_1]$$

$$\Rightarrow \boxed{I_1 + 2I_3 = 0} \quad \text{(iii)}$$

Solving (i), (ii), & (iii) ... ...

$$I_1 = -8 \text{ (mA)} \; ; \; I_2 = 8.8 \text{ (mA)} \; ; \; I_3 = 4 \text{ (mA)}$$

Power absorbed by the 4kΩ resistor,

$$P_{4k} = (I_3 - I_1)^2 \times 4k \quad (mW)$$

$$= 5.76 \quad (mW)$$

Current supplied by the 56v source

$$= I_2 - I_1$$

$$= 8.8 - (-8)$$

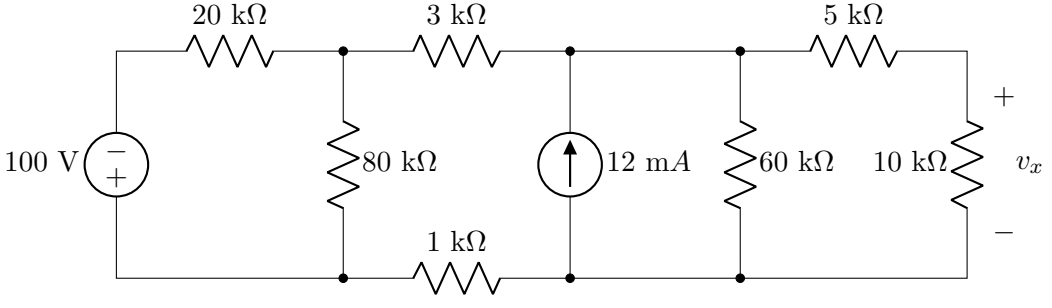
$$= 16.8 \quad (mA)$$

Power supplied by the voltage source,

$$P = -56 \times 16.8 \quad (mW)$$

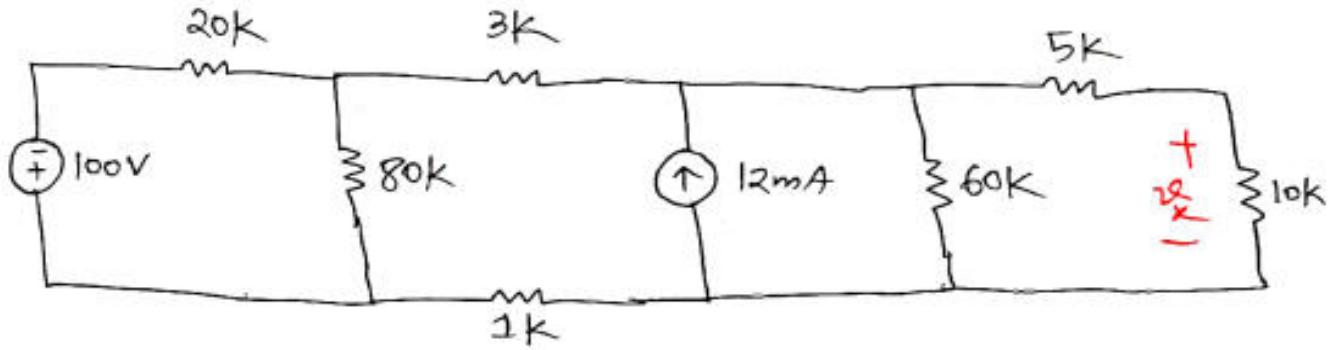
$$= -940.8 \quad (mW)$$

Question 3 of 3 *[15 marks]*

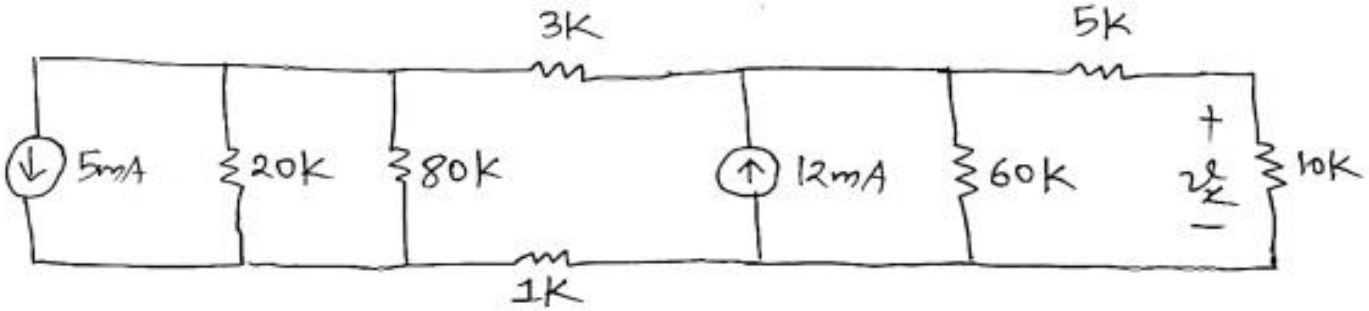


- **Determine** the voltage v_x across the 10 kΩ resistor by performing a succession of appropriate **Source Transformations**.
  (15 marks) [CO2, CO4]

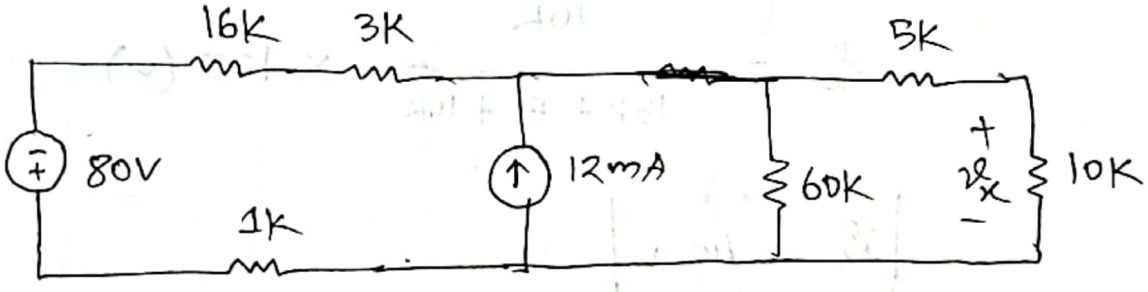
Q3



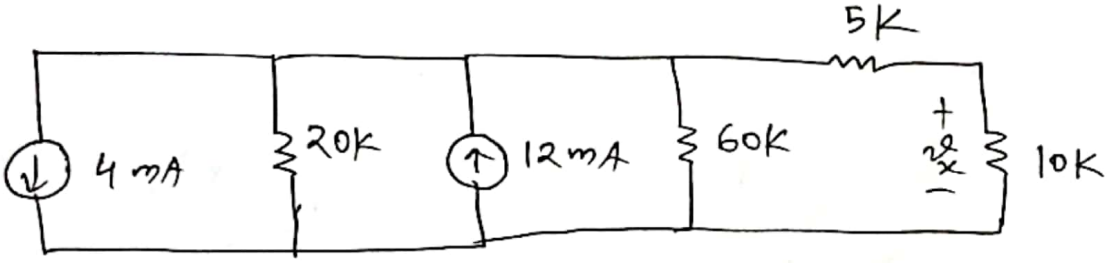
Step 1 $(100V + 20K) \longrightarrow (5mA \parallel 20K)$



Step 2 & 3 $(20K \parallel 80K = 16K)$; $(5mA \parallel 16K) \longrightarrow (80V + 16K)$

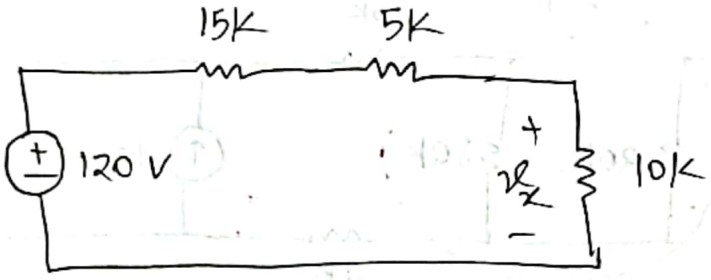


Step 4 & 5 $(16K + 3K + 1K = 20K)$; $(80V + 20K) \longrightarrow (4mA \parallel 20K)$



steps 6 & 7 $(20K \,||\, 60K = 15K)$; $(12mA - 4mA = 8mA)$

step 8 $(8mA \,||\, 15K) \longrightarrow (120V + 15K)$



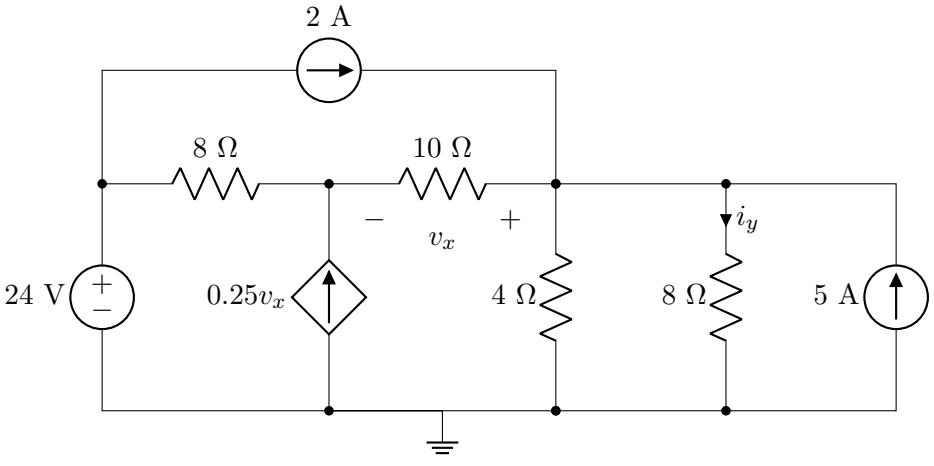
step 9 (voltage division)

$$v_x = \frac{10K}{15K + 5K + 10K} \times 120\,(V)$$

$$\boxed{v_x = 40\ V}$$

Question 1 of 3 *[20 marks]*

Set: 2

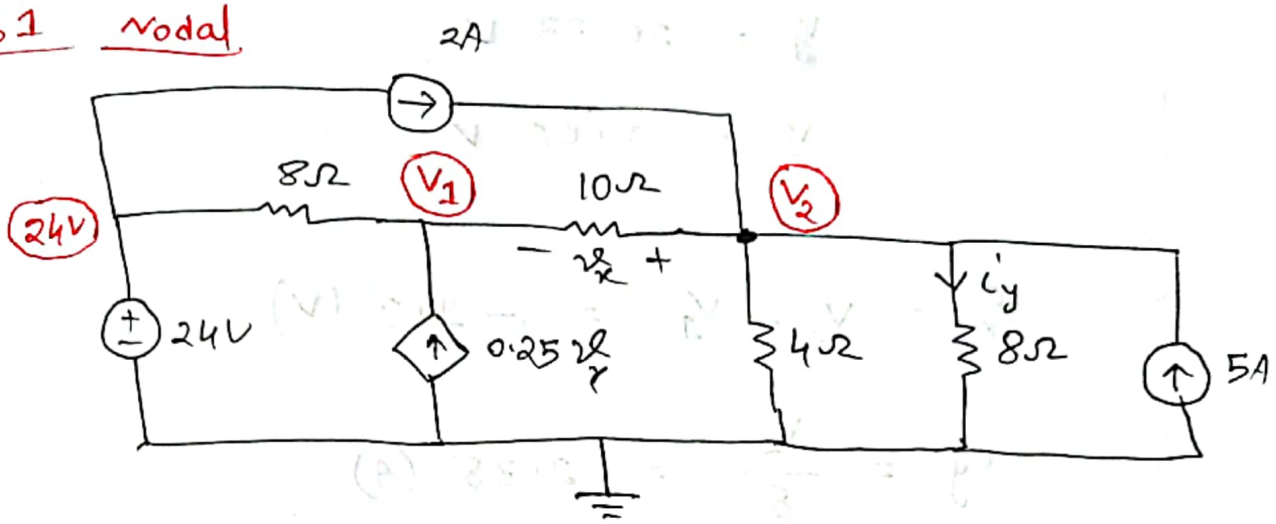


- **Apply Nodal/Mesh Analysis** to **identify** the values of the node voltages/mesh currents. *(Equations must be highlighted using boxes).* *(18 marks) [CO2, CO4]*

- **What** is the value of v_x and i_y? (with appropriate ± sign)? *(2 marks) [CO1, CO2]*

Set 2

Q1 Nodal



KCL at node 1,

$$0.25 v_x = \frac{V_1 - 24}{8} + \frac{V_1 - V_2}{10}$$

$$\Rightarrow 0.25 (V_2 - V_1) = \frac{V_1}{8} - 3 + \frac{V_1}{10} - \frac{V_2}{10} \quad \left[v_x = V_2 - V_1\right]$$

$$\Rightarrow 10V_2 - 10V_1 = 5V_1 - 120 + 4V_1 - 4V_2$$

$$\Rightarrow \boxed{19V_1 - 14V_2 = 120} \quad \text{(i)}$$

KCL at node 2,

$$2 + 5 = \frac{V_2 - V_1}{10} + \frac{V_2}{4} + \frac{V_2}{8}$$

$$\Rightarrow 280 = 4V_2 - 4V_1 + 10V_2 + 5V_2$$

$$\Rightarrow \boxed{4V_1 - 19V_2 = -280} \quad \text{(ii)}$$

solving (i) & (ii) ... ...

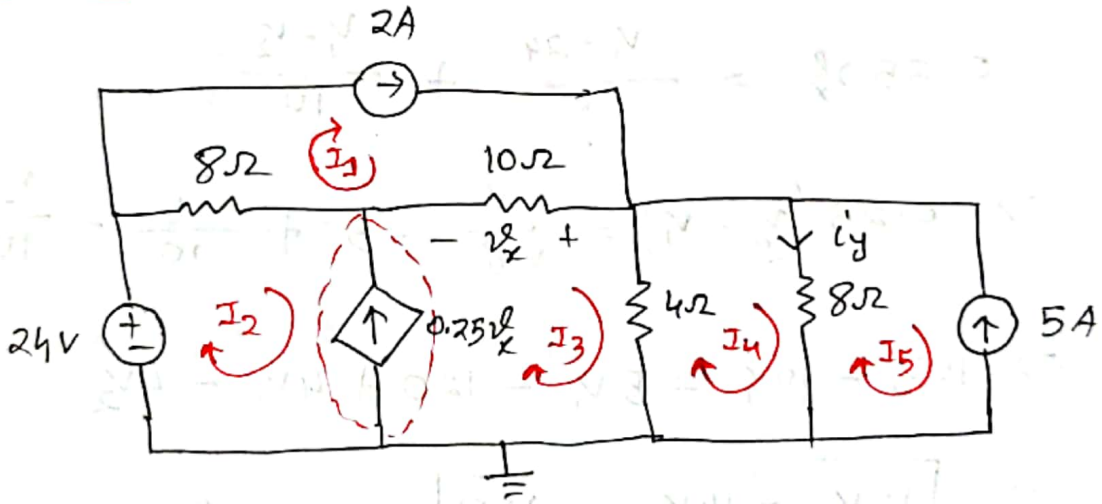
$$V_1 = 20.33 \text{ V}$$

$$V_2 = 19.02 \text{ V}$$

$$v_x = V_2 - V_1 = -1.3 \text{ (V)}$$

$$i_y = \frac{V_2}{8} = 2.38 \text{ (A)}$$

Mesh



$I_1 = 2A$

$I_5 = -5A$

KVL at mesh 2 & 3 (supermesh),

$$-24 + 8(I_2 - I_1) + 10(I_3 - I_1) + 4(I_3 - I_4) = 0$$

$$\Rightarrow -24 + 8I_2 - 16 + 10I_3 - 20 + 4I_3 - 4I_4 = 0 \quad [I_1 = 2A]$$

$$\Rightarrow \boxed{8I_2 + 14I_3 - 4I_4 = 60} \quad \text{(i)}$$

KVL at mesh 4,

$$4(I_4 - I_3) + 8(I_4 - I_5) = 0$$

$$\Rightarrow 4I_4 - 4I_3 + 8I_4 + 40 = 0 \quad [I_5 = -5]$$

$$\Rightarrow \boxed{4I_3 - 12I_4 = 40} \quad \text{(ii)}$$

At the supermesh,

$$I_3 - I_2 = 0.25 v_x$$

$$\Rightarrow I_3 - I_2 = 0.25 \times 10 (I_1 - I_3) \quad [v_x = 10(I_1 - I_3)]$$

$$\Rightarrow 2I_3 - 2I_2 = 5I_1 - 5I_3$$

$$\Rightarrow \boxed{-2I_2 + 7I_3 = 10} \quad \text{(iii)} \quad [I_1 = 2A]$$

Solving (i), (ii), & (iii) ... ...

$$I_2 = 2.46\ A$$

$$I_3 = 2.13\ A$$

$$I_4 = -2.62\ A$$

$$v_x = 10\,(I_1 - I_3)$$

$$= 10\,(2 - 2.13) = 1.3\,V$$

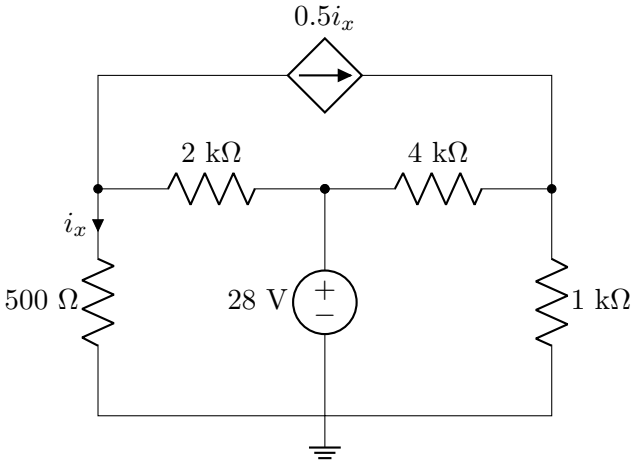
$$i_y = I_4 - I_5$$

$$= -2.62 - (-5)$$

$$= 2.38\,A$$

Question 2 of 3 *[20 marks]*

Set: 2

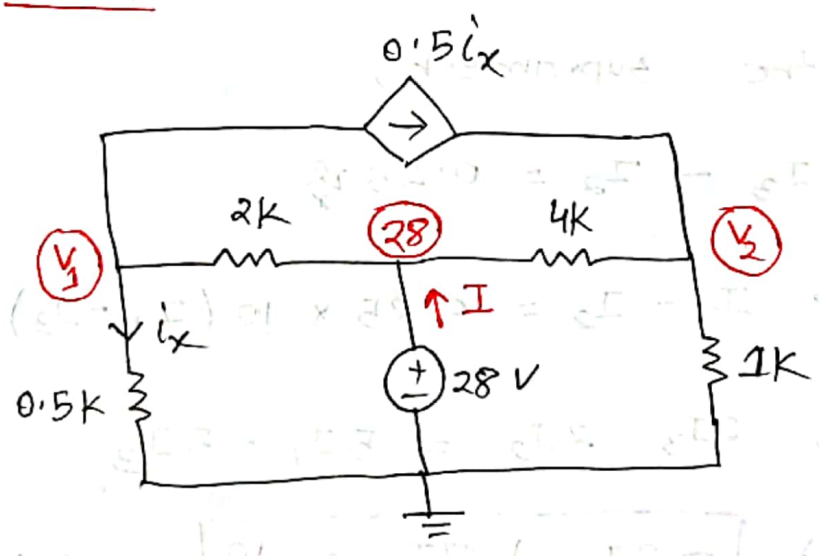


- **Apply Nodal/Mesh Analysis** to **identify** the values of the node voltages/mesh currents. *(Equations must be highlighted using boxes).*
  (14 marks) [CO2, CO4]

- **What** is the power absorbed by the 4 kΩ resistor? (with appropriate ± sign)?
  (2 marks) [CO1, CO2]

- **What** is the power supplied/absorbed by the voltage source? (with appropriate ± sign)?
  (4 marks) [CO1, CO2]

Q2 Nodal



KCL at node 1,

$$0.5 i_x + \frac{V_1 - 28}{2} + \frac{V_1}{0.5} = 0$$

$$\Rightarrow 0.5 \frac{V_1}{0.5} + \frac{V_1}{2} - 14 + \frac{V_1}{0.5} = 0 \quad \left[i_x = \frac{V_1}{0.5} \right]$$

$$\Rightarrow 2V_1 + V_1 - 28 + 4V_1 = 0$$

$$\Rightarrow \boxed{V_1 = 4V}$$

KCL at node 2,

$$0.5 i_x = \frac{V_2 - 28}{4} + \frac{V_2}{1}$$

$$\Rightarrow 0.5 \frac{V_1}{0.5} = \frac{V_2}{4} - 7 + V_2 \quad \left[i_x = \frac{V_1}{0.5} \right]$$

$$\Rightarrow 4V_1 = V_2 - 28 + 4V_2$$

$$\Rightarrow 5V_2 = 28 + 16 \quad [V_1 = 4V]$$

$$\Rightarrow \boxed{V_2 = 8.8V}$$

Power absorbed by the 4kΩ resistor,

$$P_{4K} = \frac{(28 - V_2)^2}{4K} \text{ (mW)} \quad \left[P = \frac{V^2}{R} \right]$$

$$= 92.16 \text{ (mW)}$$

Let the current supplied by the 28V source is I as shown in the figure above,

KCL at the middle node,

$$I = \frac{28 - V_1}{2} + \frac{28 - V_2}{4}$$

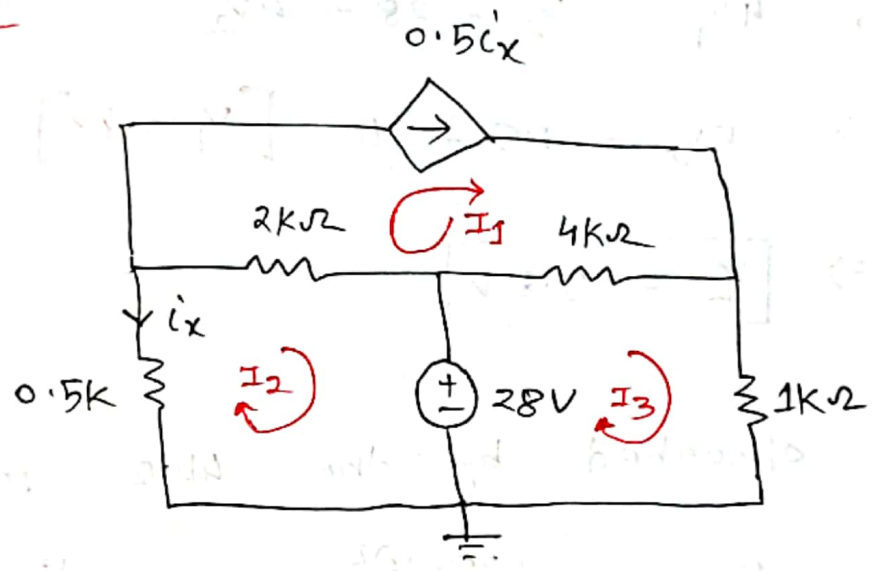
$\Rightarrow I = 16.8\ mA$

So, power supplied by the voltage source,

$= -28 \times 16.8\ (mW)$

$= -470.4\ (mW)$

Mesh



$I_1 = 0.5 i_x = -0.5 I_2$ $\quad [i_x = -I_2]$

$\Rightarrow \boxed{2I_1 + I_2 = 0}$ ——— (i)

KVL at mesh 2,

$0.5 I_2 + 2(I_2 - I_1) + 28 = 0$

$\Rightarrow I_2 + 4I_2 - 4I_1 + 56 = 0$

$$\Rightarrow \boxed{4I_1 - 5I_2 = 56} \quad \text{---(ii)}$$

KVL at mesh 3,

$$-28 + 4(I_3 - I_1) + 1I_3 = 0$$

$$\Rightarrow -28 + 4I_3 - 4I_1 + I_3 = 0$$

$$\Rightarrow \boxed{4I_1 - 5I_3 = -28} \quad \text{---(iii)}$$

solving (i), (ii), & (iii) ... ...

$$I_1 = 4 \text{ mA}$$

$$I_2 = -8 \text{ mA}$$

$$I_3 = 8.8 \text{ mA}$$

Power absorbed by the 4kΩ resistor,

$$P_{4k} = (I_3 - I_1)^2 \times 4k \text{ (mW)} \quad [P = I^2R]$$

$$= 92.16 \text{ (mW)}$$

Current supplied by the 28V source

$$= I_3 - I_2 = 8.8 - (-8) = 16.8 \text{ mA}$$

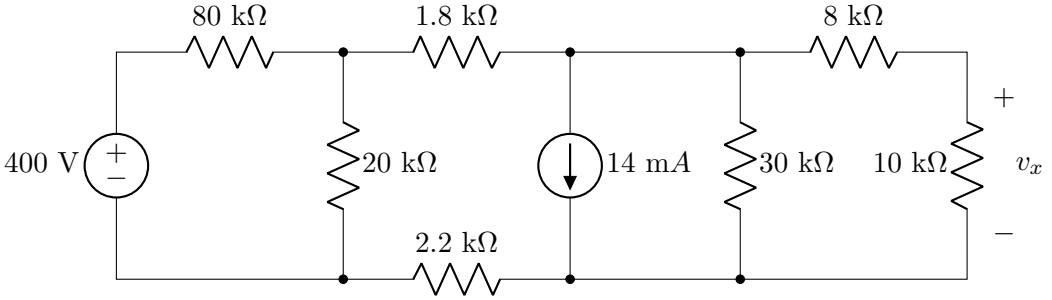
Power supplied by the voltage source

$$= -28 \times 16.8 \quad (mW)$$

$$= -470.4 \quad (mW)$$

Question 3 of 3 *[15 marks]*

Set: 2



- **Determine** the voltage v_x across the 10 kΩ resistor by performing a succession of appropriate **Source Transformations**.
  (15 marks) [CO2, CO4]

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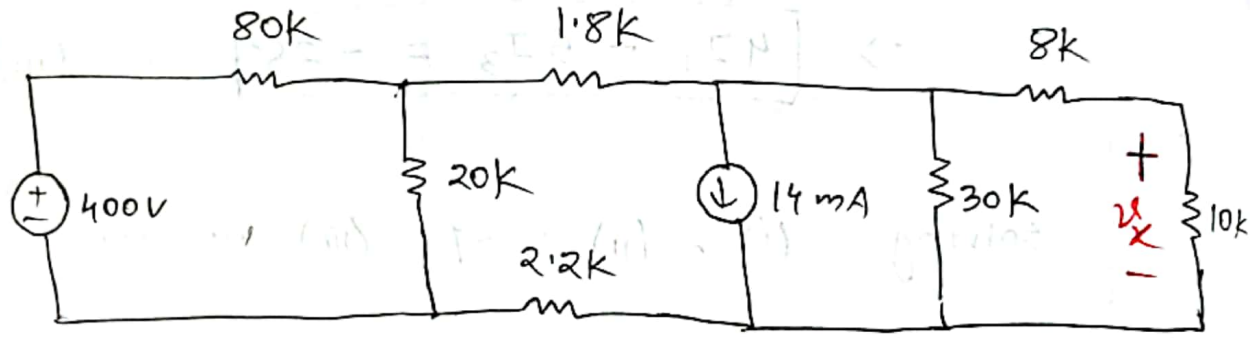
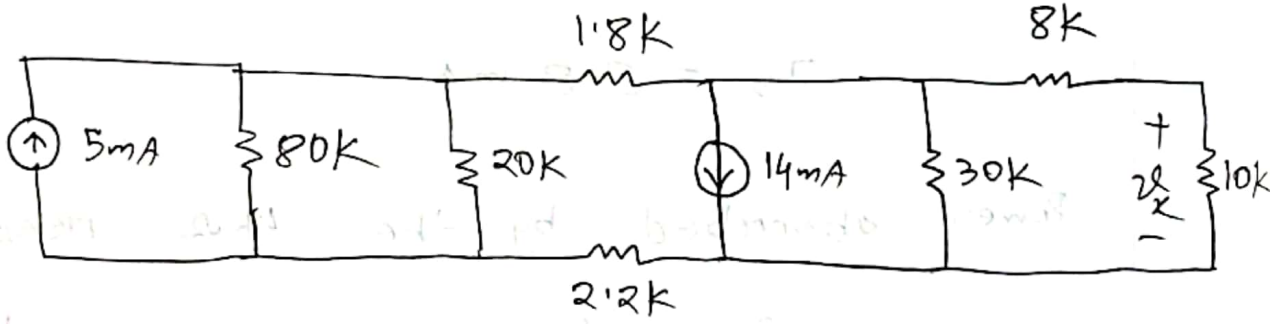
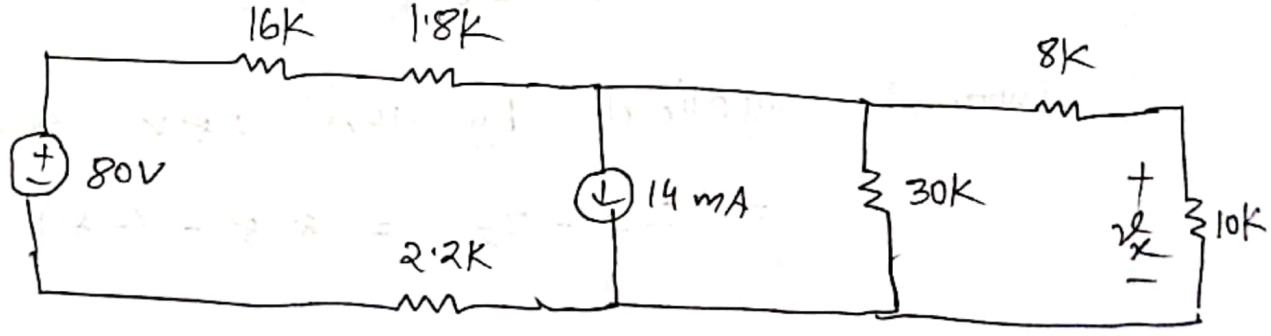


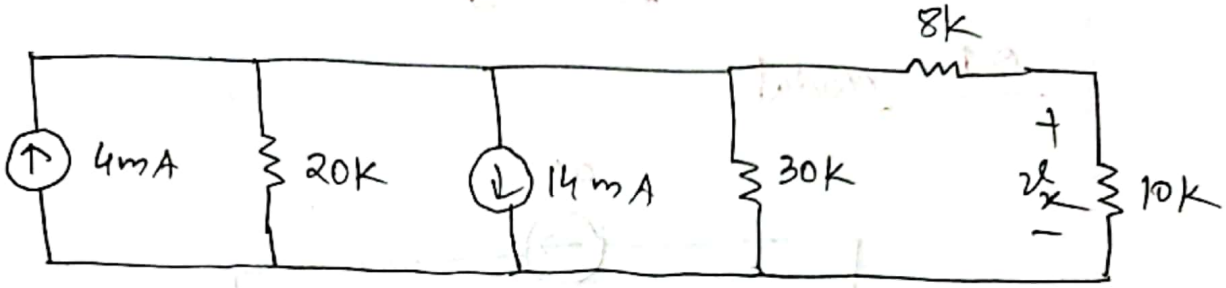
step 1 $(400V + 80K) \longrightarrow (5\,mA \,||\, 80K)$



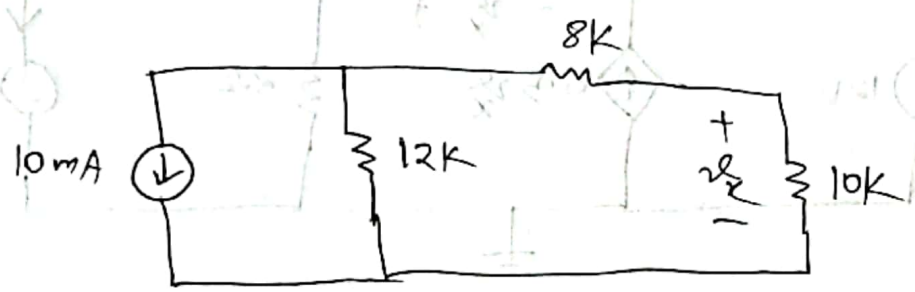
steps 2 & 3 $(80K \,||\, 20K) = 16K$; $(5mA \,||\, 16K) \longrightarrow (80V + 16K)$



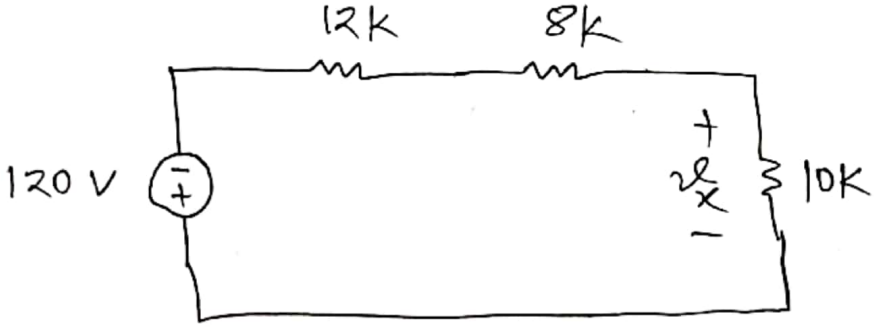
steps 4 & 5 $(16K + 1.8K + 2.2K = 20K)$; $(80V + 20K) \longrightarrow (4mA \,||\, 20K)$



steps 6 & 7 $(20K \,||\, 30K = 12K)$; $(14mA - 4mA = 10mA)$



step 8 $(10mA \,||\, 12K) \longrightarrow (120V + 12K)$



step 9 (voltage division)

$$v_x = \frac{10}{12+8+10} \times (-120)$$

$$\boxed{v_x = -40\ V}$$