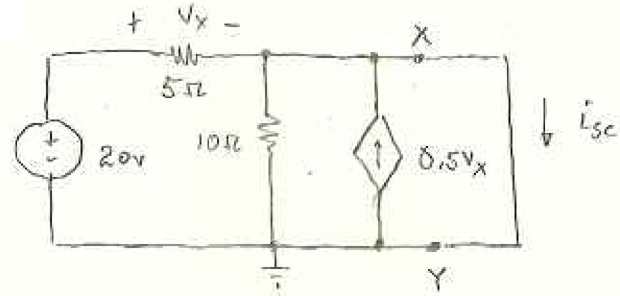
Question 1

(a)



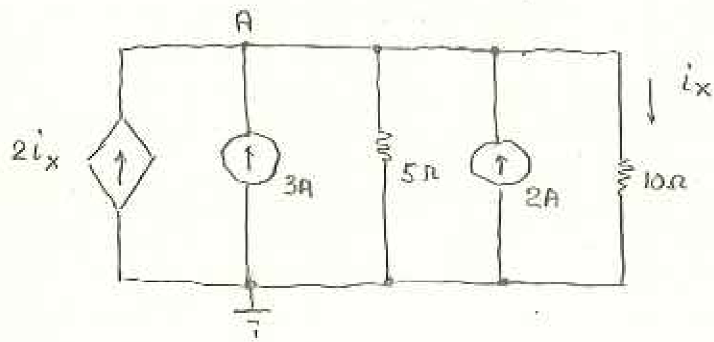
Note that both V_x and $V_y = 0$. Therefore, $V_x = 20v$.
Writing a node-voltage equation at X

$$\text{node X}: \quad \frac{V_x - 20}{5} + \frac{V_x}{10} - 0.5(20) + i_{sc} = 0$$

$$-4 + 0 - 10 + i_{sc} = 0$$

$$\boxed{i_{sc} = 14\ A}$$

(b)



At node A: $-2i_x - 3 + \frac{V_A}{5} - 2 + \frac{V_A}{10} = 0$

and $i_x = \frac{V_A}{10}$

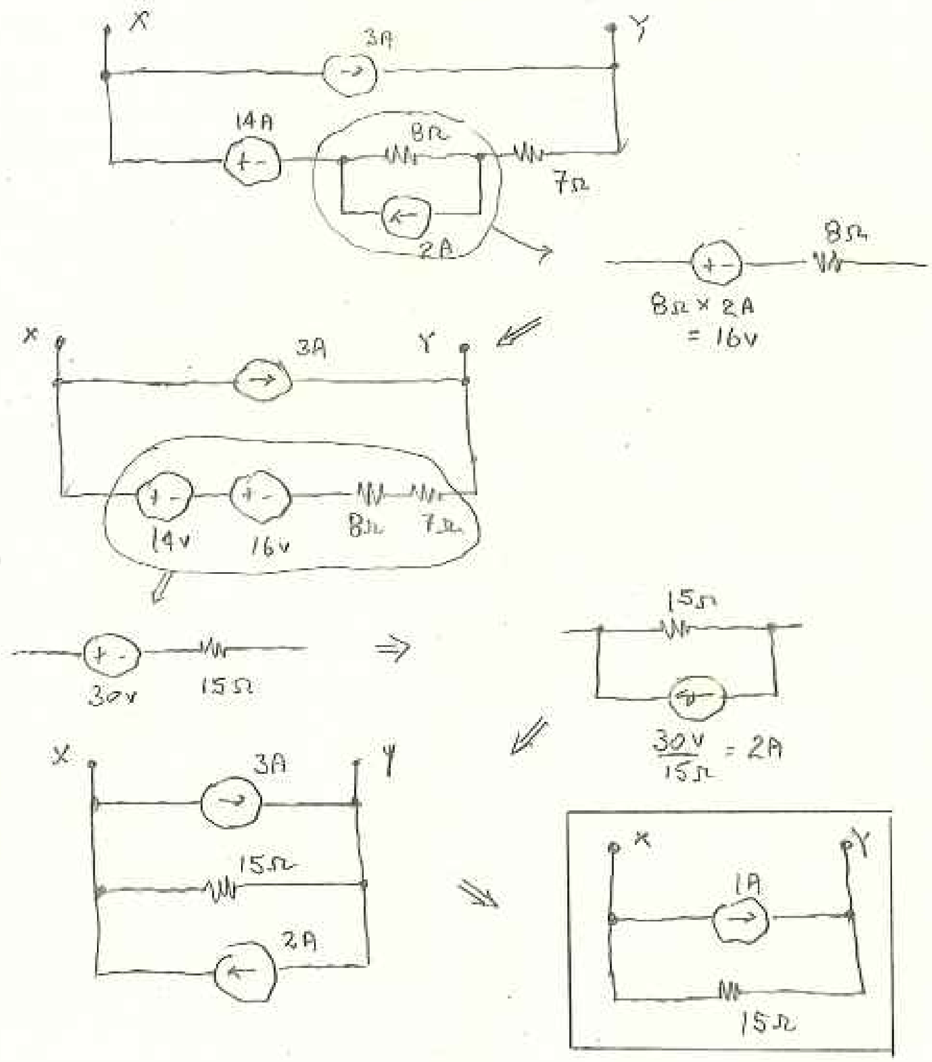
$$\text{so} \quad -2\left(\frac{V_a}{10}\right) - 5 + \frac{3V_a}{10} = 0$$

$$\frac{V_a}{10} = 5, \quad \text{so} \quad V_a = 50v$$

Power in the 3A source $\quad P_{3A} = -3A \times V_a = -150\ W$

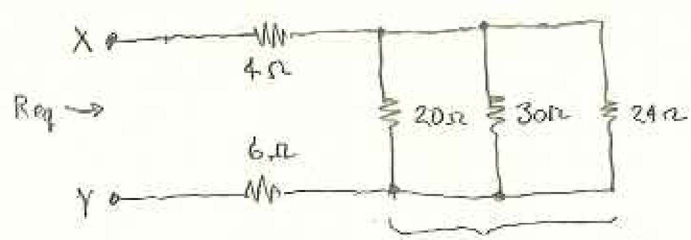
$$\boxed{|P_{3A}| = 150\ W \quad \text{delivering}}$$

(c)



(d) The cross-connection actually places the 30Ω, 24Ω, and 20Ω resistors in parallel.

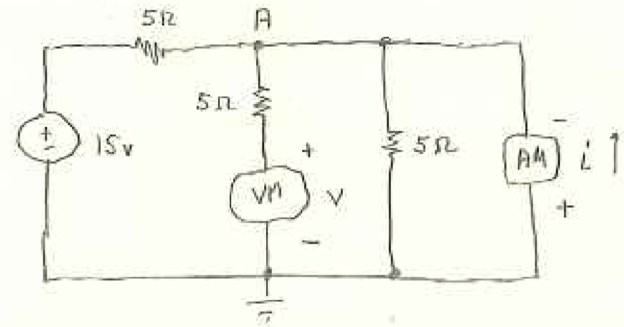
Undoing the cross-connection, ...



$20 \parallel 30 \parallel 24 = 8\Omega$

$R_{eq} = 6\Omega + 8\Omega + 4\Omega = \boxed{18\Omega}$

(e)



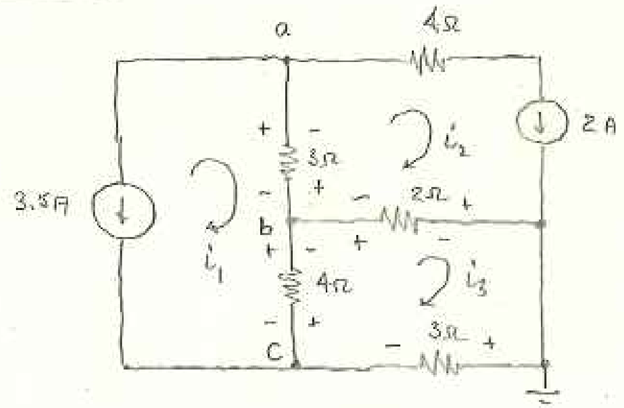
Since the ammeter behaves like a short circuit, $V_A = 0$

Therefore $\boxed{V = 0}$

No current flows in either of the middle two branches, so it all flows through the top 5Ω resistor and the ammeter

$$i = -\frac{15\text{ v}}{5\,\Omega} = \boxed{-3\text{ A}}$$

Question 2



(a) Node-voltage equations (not simplified)

Node a: $\quad 3.5 + 2 + \frac{V_a - V_b}{3} = 0$

Node b: $\quad \frac{V_b - V_a}{3} + \frac{V_b - V_c}{4} + \frac{V_b}{2} = 0$

Node c: $\quad -3.5 + \frac{V_c - V_b}{4} + \frac{V_c}{3} = 0$

(b) Mesh-current equations, using the directions indicated

mesh 1: $i_1 = -3.5\,A$

mesh 2: $i_2 = 2A$

mesh 3: $3i_3 + 4(i_3 - i_1) + 2(i_3 - i_2) = 0$

(c) Either set of equations can be used to solve for the node voltages. The simpler solution is to carry on with the mesh-current analysis

Using $i_1 = -3.5$ and $i_2 = 2$, the equation for mesh 3 becomes

$$3i_3 + 4(i_3 + 3.5) + 2(i_3 - 2) = 0$$
$$3i_3 + 4i_3 + 14 + 2i_3 - 4 = 0$$
$$9i_2 = -10$$

$$\text{so} \quad i_3 = -10/9$$

At node c: $V_c = -3i_3 = -3(-10/9) = 10/3$ v

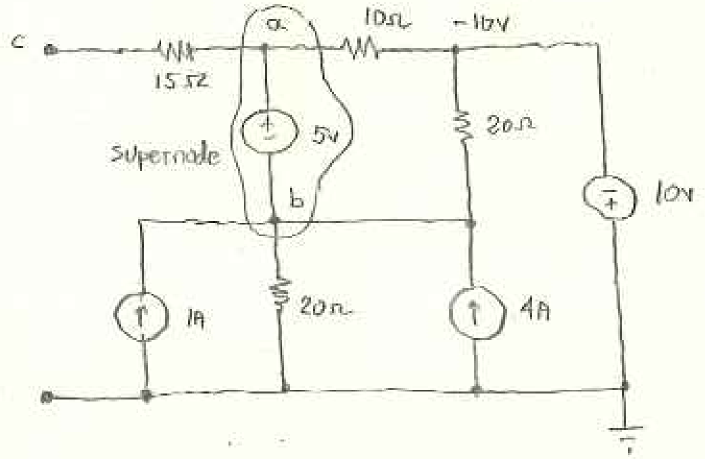
At node b: $V_b = 2(i_3 - i_2) = 2(-10/9 - 2)$
$= -56/9$
$= -6.222$ v

At node a: $V_a = V_b + 3(i_1 - i_2)$
$= -6.222 + 3(-3.5 - 2)$
$= -22.7222$ v

$$\boxed{\begin{aligned} V_a &= 3.3333 \text{ v} \\ V_b &= -6.2222 \text{ v} \\ V_c &= -22.7222 \text{ v} \end{aligned}}$$

Question 3

Finding the Thevenin equivalent for the part of the circuit in the box. First, V_t



Using the node-voltage method, there is one supernode

supernode a,b: $\frac{V_a - (-10)}{10} + \frac{V_b}{20} + \frac{V_b - (-10)}{20} - 4 - 1 = 0$

$(\times 20)$ $2V_a + 20 + V_b + V_b + 10 - 80 - 20 = 0$

$$2V_a + 2V_b = 70 \qquad (1)$$

supernode dependence: $V_a - V_b = 5$

so $V_b = V_a - 5 \qquad (2)$

Substituting (2) into (1): $2V_a + 2V_a - 10 = 70$

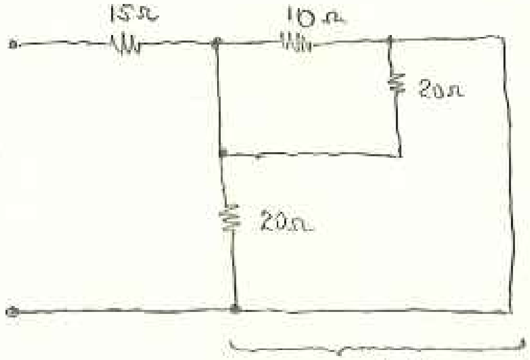
$4V_a = 80$

$V_a = 20\text{ v}$

With terminal c open, no current flows through the 15Ω resistor

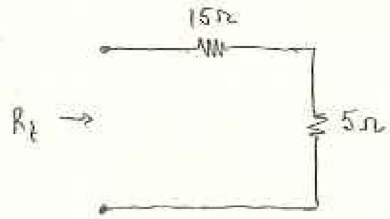
so $V_c = V_a = V_t = 20\text{ v}$

Now find R_t. There are no dependent sources, so we may zero the independent ones.



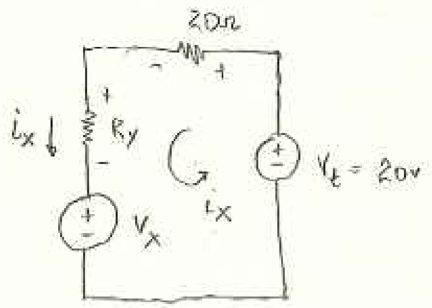
all three resistors in parallel
$10 \,//\, 20 \,//\, 20 = 5\Omega$

so



so $R_t = 15 + 5 = 20\Omega$

The overall equivalent circuit is



KVL around the loop gives

$$V_x - 20 + 20 i_x + i_x R_x = 0$$
$$V_x - 20 + i_x (20 + R_x) = 0$$

so
$$i_x = \frac{-(V_x - 20)}{20 + R_x}$$
$$i_x = \frac{20 - V_x}{20 + R_x}$$

Using this simple formula ...

$V_x = 5, \; R_x = 10$: $\quad i_x = \dfrac{20 - 5}{20 + 10} = 0.5\,A$

$V_x = 10, \; R_x = 30$: $\quad i_x = \dfrac{20 - 10}{20 + 30} = 0.2\,A$

$V_x = 0, \; R_x = 0$: $\quad i_x = \dfrac{20}{20} = 1\,A$