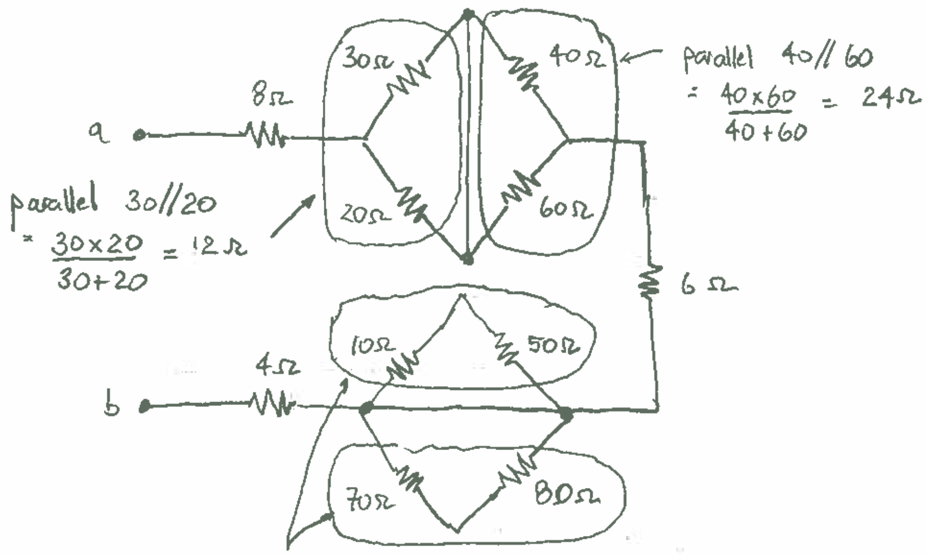
Question 1

(a)

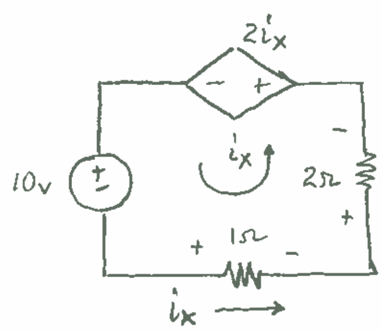


Series resistors in parallel with a short-circuit.

Total equivalent resistance $R_{ab} = 8 + 12 + 24 + 6 + 4$

$$\boxed{R_{ab} = 54\Omega}$$

(b)



Defining a loop current i_x as shown, we may write a KVL equation

$$10 + 1 \cdot i_x + 2 \cdot i_x + 2i_x = 0$$
$$10 + 5i_x = 0$$

so $i_x = -2A$

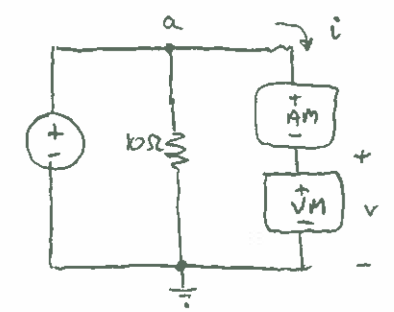
Using the passive reference convention for the dependent source,

$$P_{2i_x} = +\underbrace{(2i_x)}_{\text{voltage}}\underbrace{(i_x)}_{\text{current}}$$

$$= (-4)(-2) = 8\ W$$

$$\boxed{P_{2i_x} = 8W \text{ (absorbing)}}$$

(c)



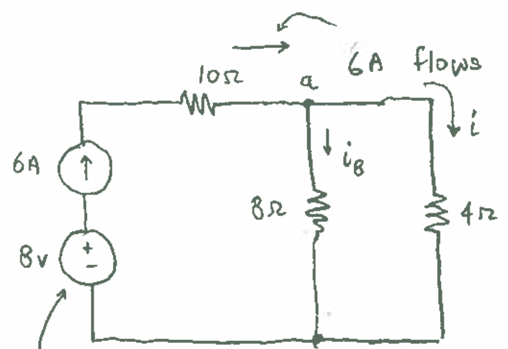
Since the voltmeter behaves like an open circuit, no current flows

$\boxed{i = 0}$

Since the ammeter behaves like a short circuit, the voltage across the voltmeter will be $V = V_a$

$\boxed{V = 5v}$

(d)



6A flows into node A irrespective of the voltage source and 10Ω resistor.

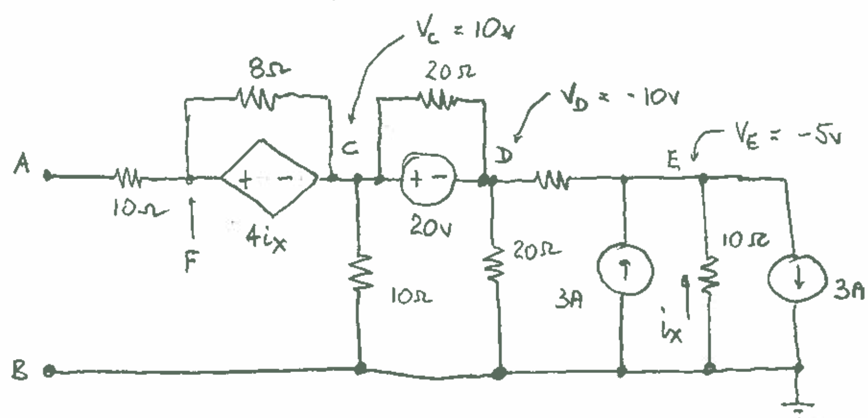
Voltage source does not influence the calculation.

We have a simple current divider

$$i = \frac{8\Omega}{8+4} \times 6\,A = 4A$$

$\boxed{i = 4A}$

(e)

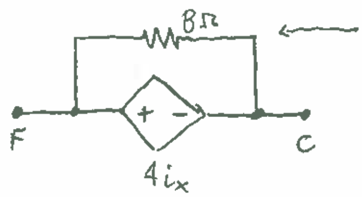


A complete analysis of this circuit is unnecessary. The key steps involve simply calculating i_x and the voltage at F.

Since we know $V_E = -5v$, then i_x, as drawn, will be

$$i_x = \frac{0 - V_E}{10} = \frac{0-(-5)}{10} = 0.5\text{ A}$$

Then at node F, we see that $V_F - V_C = 4i_x$



A resistor in parallel with a voltage source has <u>no effect</u> on the voltage of the source. Ignore this resistor.

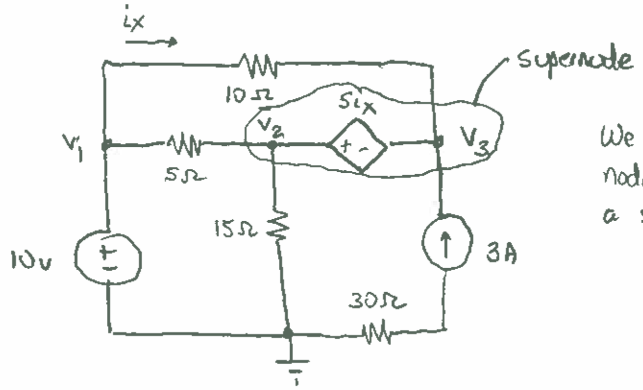
With $V_C = 10v$, then
$$\begin{aligned} V_F &= V_C + 4i_x \\ &= 10 + 4(0.5) \\ &= 12v \end{aligned}$$

Finally, since the terminal A is open-circuited, $V_A = V_F$

$$\boxed{V_A = 12v}$$

Question 2

(a) Node-voltage method



We know $V_1 = 10$, and nodes 2 and 3 form a supernode

$$\boxed{V_1 = 10v}$$

Supernode equation: $\dfrac{V_2 - \overset{10v}{V_1}}{5} + \dfrac{V_2}{15} + \dfrac{V_3 - \overset{10v}{V_1}}{10} - 3 = 0$

$(\times 30)$ $\quad 6V_2 - 60 + 2V_2 + 3V_3 - 30 - 90 = 0$

$$8V_2 + 3V_3 = 180 \quad \longleftarrow (1)$$

Supernode dependence: $V_2 - V_3 = 5 i_x$

where $i_x = \dfrac{V_1 - V_3}{10} = \dfrac{10 - V_3}{10}$

so $V_2 - V_3 = 5\left(\dfrac{10 - V_3}{10}\right)$

$V_2 - V_3 = 5 - \dfrac{V_3}{2}$

so $V_2 - 5 = \dfrac{V_3}{2}$

or $V_3 = 2V_2 - 10 \quad \longleftarrow (2)$

Combining (1) and (2)

$8V_2 + 3(2V_2 - 10) = 180$

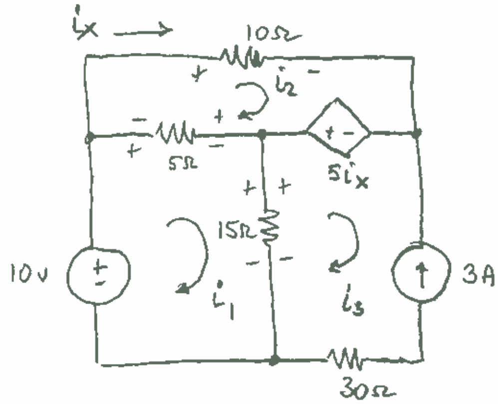
$14V_2 = 210$

$$\boxed{V_2 = 15v}$$

and $V_3 = 2(15) - 10 = 20v$

$$\boxed{V_3 = 20v}$$

(b) Mesh-current method



We know immediately that

$\boxed{i_3 = -3A}$

and that $i_x = i_2$.

Two mesh equations needed.

$i_3 = -3A$

Mesh 1: $-10 + 5(i_1 - i_2) + 15(i_1 - i_3) = 0$

$-10 + 20i_1 - 5i_2 + 45 = 0$

$20i_1 - 5i_2 = -35 \quad \longleftarrow (1)$

$i_x = i_2$

Mesh 2: $5(i_2 - i_1) + 10i_2 - 5i_x = 0$

$10i_2 - 5i_1 = 0$

$i_1 = 2i_2 \quad \longleftarrow (2)$

Substitute (2) into (1)

$20(2i_2) - 5i_2 = -35$

$35i_2 = -35$

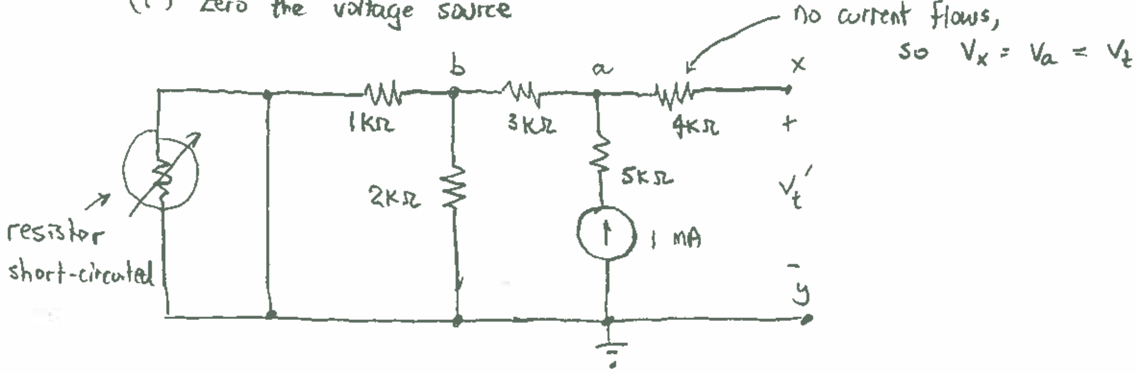
so $\boxed{i_2 = -1\text{ A}}$

and from (2), $\boxed{i_1 = -2A}$

Question (3)

(a) Thevenin voltage by superposition.

(i) Zero the voltage source



Node-voltage method, where $V_t' = V_a$.

Node a: $-0.001 + \dfrac{V_a - V_b}{3000} = 0$

(x3000) $-3 + V_a - V_b = 0$ (1)

Node b: $\dfrac{V_b}{1000} + \dfrac{V_b}{2000} + \dfrac{V_b - V_a}{3000} = 0$

(x 6000) $6V_b + 3V_b + 2V_b - 2V_a = 0$

$11 V_b = 2 V_a$ (2)

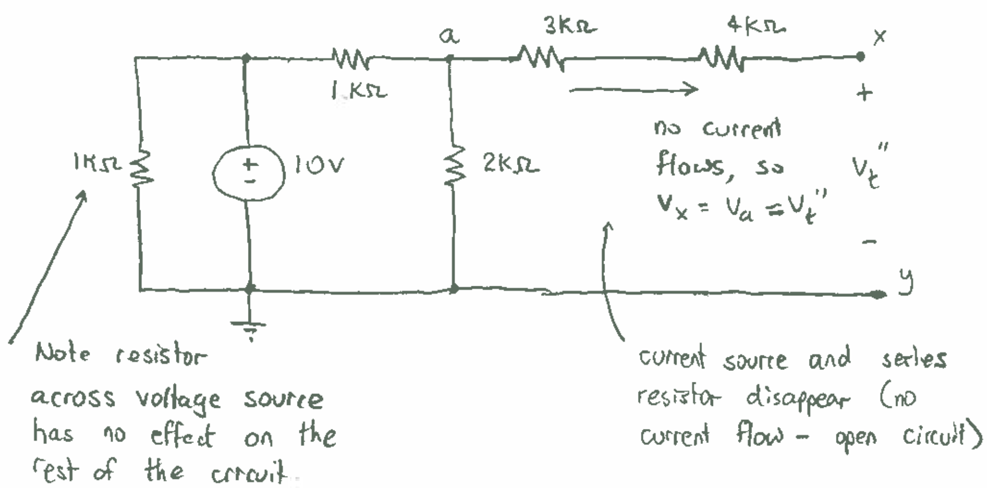
From (1), $V_b = V_a - 3$, so $11(V_a - 3) = 2V_a$

$11 V_a - 2V_a = 33$

$V_a = 3.667$ v

Thus, $V_t' = 3.667$ v

(ii) Zero the current source



Here we have a simple resistor voltage divider,

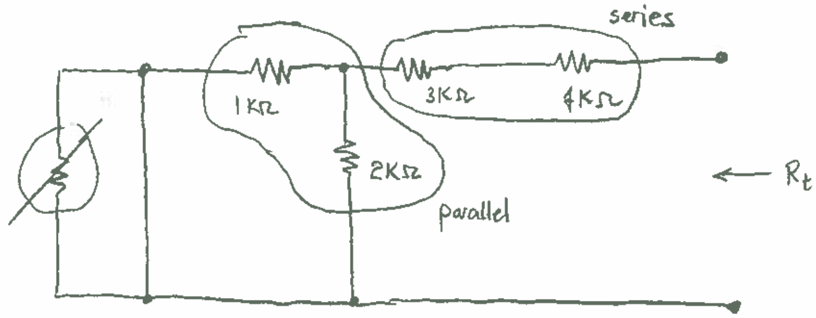
$$\text{so} \quad V_t'' = \frac{2000}{2000 + 1000} \times 10 = 6.667\text{ v}$$

Finally, by superposition

$$V_t = V_t' + V_t''$$
$$= 3.667 + 6.667$$

$$\boxed{V_t = 10.333\text{ v}}$$

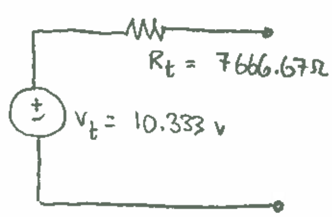
(b) Thevenin resistance. There are no dependent sources, so we may zero the sources.



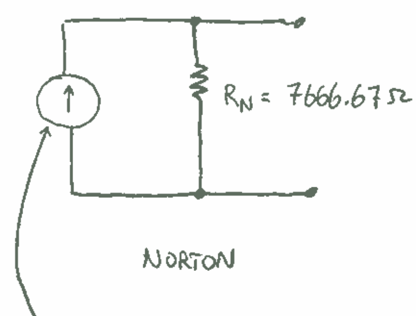
By inspection : $R_t = (1K\Omega \,/\!/\, 2K\Omega) + 3K\Omega + 4K\Omega$

$$\boxed{R_t = 7666.67\,\Omega}$$

(c) The Norton equivalent circuit



THEVENIN



NORTON

$$i_n = \frac{V_t}{R_t} = \frac{10.333}{7666.67}$$

$$= 1.348 \text{ mA}$$