P 2.6 [a] Because both current sources are in the same branch of the circuit, their values must be the same. Therefore,

$$\frac{v_1}{50} = 0.4 \qquad \longrightarrow \qquad v_1 = 0.4(50) = 20\ \text{V}$$

[b] $p = v_1(0.4) = (20)(0.4) = 8$ W (absorbed)

P 2.7 [a] The voltage drop from the top node to the bottom node in this circuit must be the same for every path from the top to the bottom. Therefore, the voltages of the two voltage sources are equal:

$$-\alpha i_\Delta = 6$$

Also, the current i_Δ is in the same branch as the 15 mA current source, but in the opposite direction, so

$$i_\Delta = -0.015$$

Substituting,

$$-\alpha(-0.015) = 6 \qquad \longrightarrow \qquad \alpha = \frac{6}{0.015} = 400$$

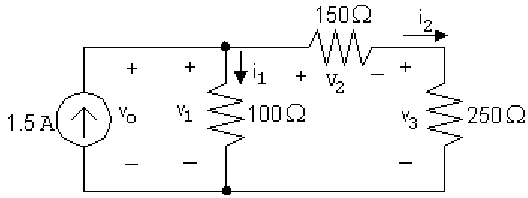
The interconnection is valid if $\alpha = 400$ V/A.

[b] The voltage across the current source must equal the voltage across the 6 V source, since both are connected between the top and bottom nodes. Using the passive sign convention,

$$p = vi = (6)(0.015) = 0.09 = 90\ \text{mW}$$

[c] Since the power is positive, the current source is absorbing power.

P 2.19



[a] Write a KCL equation at the top node:

$$-1.5 + i_1 + i_2 = 0 \qquad \text{so} \qquad i_1 + i_2 = 1.5$$

Write a KVL equation around the right loop:

$$-v_1 + v_2 + v_3 = 0$$

From Ohm's law,

$$v_1 = 100i_1, \qquad v_2 = 150i_2, \qquad v_3 = 250i_2$$

Substituting,

$$-100i_1 + 150i_2 + 250i_2 = 0 \qquad \text{so} \qquad -100i_1 + 400i_2 = 0$$

Solving the two equations for i_1 and i_2 simultaneously,

$$i_1 = 1.2\,\text{A} \qquad \text{and} \qquad i_2 = 0.3\,\text{A}$$

[b] Write a KVL equation clockwise around the left loop:

$$-v_o + v_1 = 0 \qquad \text{but} \qquad v_1 = 100i_1 = 100(1.2) = 120\,\text{V}$$

So $\quad v_o = v_1 = 120\,\text{V}$

[c] Calculate power using $p = vi$ for the source and $p = Ri^2$ for the resistors:

$$p_{\text{source}} = -v_o(1.5) = -(120)(1.5) = -180\,\text{W}$$

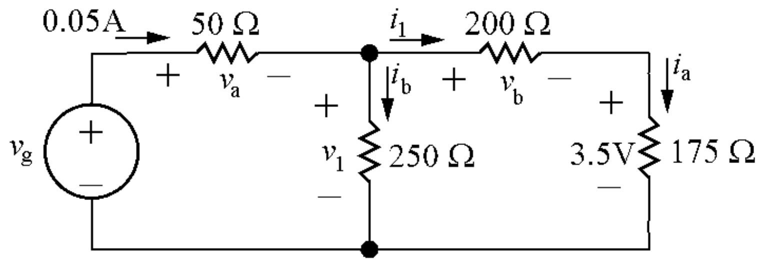
$$p_{100\Omega} = 1.2^2(100) = 144\,\text{W}$$

$$p_{150\Omega} = 0.3^2(150) = 13.5\,\text{W}$$

$$p_{250\Omega} = 0.3^2(250) = 22.5\,\text{W}$$

$$\sum P_{\text{dev}} = 180\,\text{W} \qquad \sum P_{\text{abs}} = 144 + 13.5 + 22.5 = 180\,\text{W}$$

P 2.20 Label the unknown resistor voltages and currents:



[a] $i_a = \dfrac{3.5}{175} = 0.02\,\text{A}$ (Ohm's law)

$i_1 = i_a = 0.02\,\text{A}$ (KCL)

[b] $v_b = 200i_1 = 200(0.02) = 4\,\text{V}$ (Ohm's law)

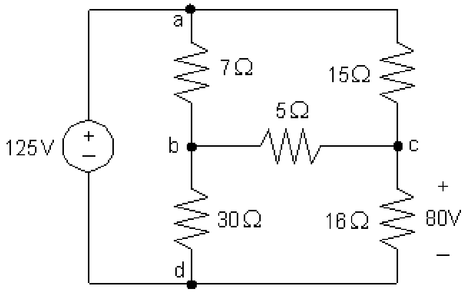
$-v_1 + v_b + 3.5 = 0$ so $v_1 = 3.5 + v_b = 3.5 + 4 = 7.5\,\text{V}$ (KVL)

[c] $v_a = 0.05(50) = 2.5\,\text{V}$ (Ohm's law)

$-v_g + v_a + v_1 = 0$ so $v_g = v_a + v_1 = 2.5 + 7.5 = 10\,\text{V}$ (KVL)

[d] $p_g = v_g(0.05) = 10(0.05) = 0.5\,\text{W}$

P 2.25 [**a**]



$i_{\text{cd}} = 80/16 = 5\,\text{A}$

$v_{\text{ac}} = 125 - 80 = 45$ so $i_{\text{ac}} = 45/15 = 3\,\text{A}$

$i_{\rm ac} + i_{\rm bc} = i_{\rm cd}$ so $i_{\rm bc} = 5 - 3 = 2\,\text{A}$

$v_{\rm ab} = 15i_{\rm ac} - 5i_{\rm bc} = 15(3) - 5(2) = 35\,\text{V}$ so $i_{\rm ab} = 35/7 = 5\,\text{A}$

$i_{\rm bd} = i_{\rm ab} - i_{\rm bc} = 5 - 2 = 3\,\text{A}$

Calculate the power dissipated by the resistors using the equation $p_R = Ri_R^2$:

$p_{7\Omega} = (7)(5)^2 = 175\,\text{W}$ $p_{30\Omega} = (30)(3)^2 = 270\,\text{W}$

$p_{15\Omega} = (15)(3)^2 = 135\,\text{W}$ $p_{16\Omega} = (16)(5)^2 = 400\,\text{W}$

$p_{5\Omega} = (5)(2)^2 = 20\,\text{W}$

[**b**] Calculate the current through the voltage source:

$i_{\rm ad} = -i_{\rm ab} - i_{\rm ac} = -5 - 3 = -8\,\text{A}$

Now that we have both the voltage and the current for the source, we can calculate the power supplied by the source:

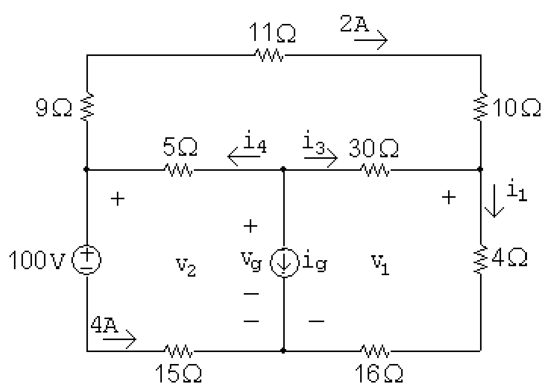
$p_g = 125(-8) = -1000\,\text{W}$ thus p_g (supplied) $= 1000\,\text{W}$

[**c**] $\sum P_{\rm dis} = 175 + 270 + 135 + 400 + 20 = 1000\,\text{W}$

Therefore,

$\sum P_{\rm supp} = \sum P_{\rm dis}$

P 2.26 [**a**]



$v_2 = 100 + 4(15) = 160\,\text{V};$ $v_1 = 160 - (9 + 11 + 10)(2) = 100\,\text{V}$

$i_1 = \dfrac{v_1}{4 + 16} = \dfrac{100}{20} = 5\,\text{A};$ $i_3 = i_1 - 2 = 5 - 2 = 3\,\text{A}$

$v_g = v_1 + 30i_3 = 100 + 30(3) = 190\,\text{V}$

$i_4 = 2 + 4 = 6\,\text{A}$

$i_g = -i_4 - i_3 = -6 - 3 = -9\,\text{A}$

[**b**] Calculate power using the formula $p = Ri^2$:

$$p_{9\,\Omega} = (9)(2)^2 = 36\,\text{W}; \qquad p_{11\,\Omega} = (11)(2)^2 = 44\,\text{W}$$

$$p_{10\,\Omega} = (10)(2)^2 = 40\,\text{W}; \qquad p_{5\,\Omega} = (5)(6)^2 = 180\,\text{W}$$

$$p_{30\,\Omega} = (30)(3)^2 = 270\,\text{W}; \qquad p_{4\,\Omega} = (4)(5)^2 = 100\,\text{W}$$

$$p_{16\,\Omega} = (16)(5)^2 = 400\,\text{W}; \qquad p_{15\,\Omega} = (15)(4)^2 = 240\,\text{W}$$

[**c**] $v_g = 190\,\text{V}$

[**d**] Sum the power dissipated by the resistors:

$$\sum p_{\text{diss}} = 36 + 44 + 40 + 180 + 270 + 100 + 400 + 240 = 1310\,\text{W}$$

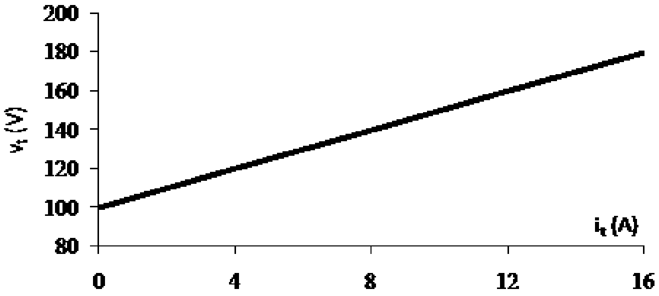
The power associated with the sources is

$$p_{\text{volt}-\text{source}} = (100)(4) = 400\,\text{W}$$

$$p_{\text{curr}-\text{source}} = v_g i_g = (190)(-9) = -1710\,\text{W}$$

Thus the total power dissipated is $1310 + 400 = 1710$ W and the total power developed is 1710 W, so the power balances.

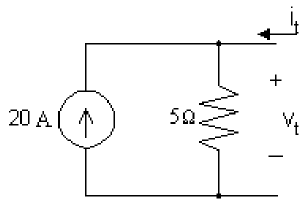
P 2.29 **[a]** Plot the v—i characteristic:



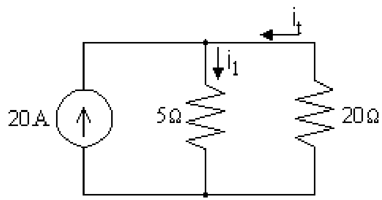
From the plot:

$$R = \frac{\Delta v}{\Delta i} = \frac{(180 - 100)}{(16 - 0)} = 5\,\Omega$$

When $i_t = 0$, $v_t = 100$ V; therefore the ideal current source must have a current of $100/5 = 20$ A



[b] We attach a $20\,\Omega$ resistor to the device model developed in part (a):



Write a KCL equation at the top node:

$20 + i_t = i_1$

Write a KVL equation for the right loop, in the direction of the two currents, using Ohm's law:

$5i_1 + 20i_t = 0$

Combining the two equations and solving,

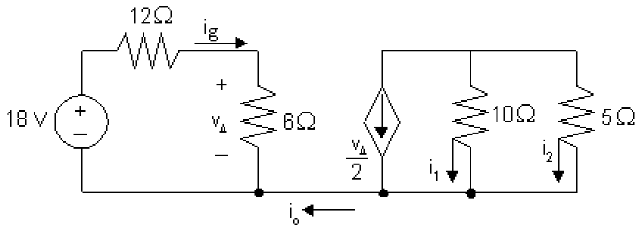
$5(20 + i_t) + 20i_t = 0$ so $25i_t = -100;$ thus $i_t = -4\,\text{A}$

Now calculate the power dissipated by the resistor:

$p_{20\,\Omega} = 20i_t^2 = 20(-4)^2 = 320\,\text{W}$

P 2.35 [**a**] $i_o = 0$ because no current can exist in a single conductor connecting two parts of a circuit.

[**b**]



$$18 = (12 + 6)i_g \qquad i_g = 1 \text{ A}$$

$$v_\Delta = 6i_g = 6\text{V} \qquad v_\Delta/2 = 3 \text{ A}$$

$$10i_1 = 5i_2, \text{ so } i_1 + 2i_1 = -3 \text{ A; therefore, } i_1 = -1 \text{ A}$$

[**c**] $i_2 = 2i_1 = -2$ A.

P 2.36 **[a]** $-50 - 20i_\sigma + 18i_\Delta = 0$

$-18i_\Delta + 5i_\sigma + 40i_\sigma = 0 \quad \text{so} \quad 18i_\Delta = 45i_\sigma$

Therefore, $\quad -50 - 20i_\sigma + 45i_\sigma = 0, \quad \text{so} \quad i_\sigma = 2\,\text{A}$

$18i_\Delta = 45i_\sigma = 90;\ \text{so}\ i_\Delta = 5\,\text{A}$

$v_o = 40i_\sigma = 80\,\text{V}$

[b] i_g = current out of the positive terminal of the 50 V source
v_d = voltage drop across the $8i_\Delta$ source

$i_g = i_\Delta + i_\sigma + 8i_\Delta = 9i_\Delta + i_\sigma = 47\,\text{A}$

$v_d = 80 - 20 = 60\,\text{V}$

$$\begin{aligned}
\sum P_\text{gen} &= 50i_g + 20i_\sigma i_g = 50(47) + 20(2)(47) = 4230\ \text{W} \\
\sum P_\text{diss} &= 18i_\Delta^2 + 5i_\sigma(i_g - i_\Delta) + 40i_\sigma^2 + 8i_\Delta v_d + 8i_\Delta(20) \\
&= (18)(25) + 10(47 - 5) + 4(40) + 40(60) + 40(20) \\
&= 4230\ \text{W; Therefore,} \\
\sum P_\text{gen} &= \sum P_\text{diss} = 4230\ \text{W}
\end{aligned}$$