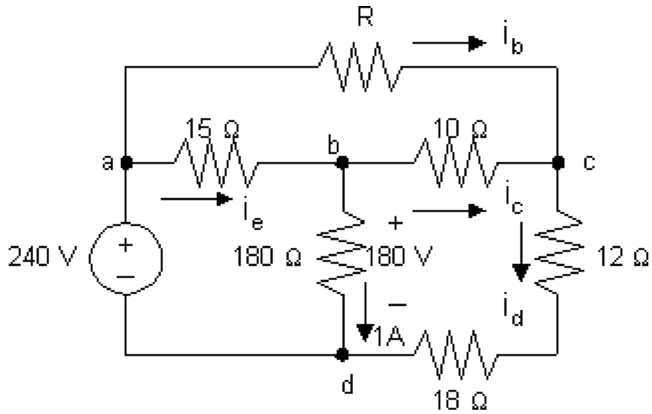
P 2.24



$v_{ab} = 240 - 180 = 60\,\text{V}$; therefore, $i_e = 60/15 = 4\,\text{A}$
$i_c = i_e - 1 = 4 - 1 = 3\,\text{A}$; therefore, $v_{bc} = 10i_c = 30\,\text{V}$
$v_{cd} = 180 - v_{bc} = 180 - 30 = 150\,\text{V}$;
  therefore, $i_d = v_{cd}/(12 + 18) = 150/30 = 5\,\text{A}$
$i_b = i_d - i_c = 5 - 3 = 2\,\text{A}$
$v_{ac} = v_{ab} + v_{bc} = 60 + 30 = 90\,\text{V}$
$R = v_{ac}/i_b = 90/2 = 45\,\Omega$

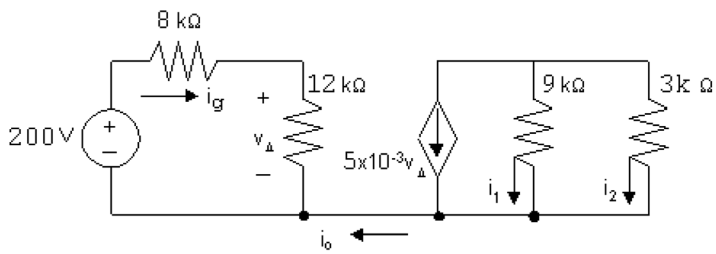
CHECK: $i_g = i_b + i_e = 2 + 4 = 6$ A

$p_{dev} = (240)(6) = 1440$ W

$\sum P_{dis} =$ $1(180) + 4(45) + 9(10) + 25(12) + 25(18) + 16(15) = 1440$ W (CHECKS)

P 2.28 **[a]** $i_o = 0$ because no current can exist in a single conductor connecting two parts of a circuit.

[b]



$-200 + 8000i_g + 12{,}000i_g = 0$ so $i_g = 200/20{,}000 = 10$ mA

$v_\Delta = (12 \times 10^3)(10 \times 10^{-3}) = 120$ V

$5 \times 10^{-3} v_\Delta = 0.6$ A

$9000i_1 = 3000i_2$ so $i_2 = 3i_1$

$0.6 + i_1 + i_2 = 0$ so $0.6 + i_1 + 3i_1 = 0$ thus $i_1 = -0.15$ A

[c] $i_2 = 3i_1 = -0.45$ A

P 2.26 **[a]** Start with the $22.5\,\Omega$ resistor. Since the voltage drop across this resistor is 90 V, we can use Ohm's law to calculate the current:

$$i_{22.5\,\Omega} = \frac{90\,\text{V}}{22.5\,\Omega} = 4\,\text{A}$$

Next we can calculate the voltage drop across the $15\,\Omega$ resistor by writing a KVL equation around the outer loop of the circuit:

$$-240\,\text{V} + 90\,\text{V} + v_{15\,\Omega} = 0 \qquad \text{so} \qquad v_{15\,\Omega} = 240 - 90 = 150\,\text{V}$$

Now that we know the voltage drop across the $15\,\Omega$ resistor, we can use Ohm's law to find the current in this resistor:

$$i_{15\,\Omega} = \frac{150\,\text{V}}{15\,\Omega} = 10\,\text{A}$$

Write a KCL equation at the middle right node to find the current through the $5\,\Omega$ resistor. Sum the currents entering:

$$4\,\text{A} - 10\,\text{A} + i_{5\,\Omega} = 0 \qquad \text{so} \qquad i_{5\,\Omega} = 10\,\text{A} - 4\,\text{A} = 6\,\text{A}$$

Write a KVL equation clockwise around the upper right loop, starting below the $4\,\Omega$ resistor. Use Ohm's law to express the voltage drop across the resistors in terms of the current through the resistors:

$$-v_{4\,\Omega} + 90\,\text{V} + (5\,\Omega)(-6\,\text{A}) = 0 \qquad \text{so} \qquad v_{4\,\Omega} = 90\,\text{V} - 30\,\text{V} = 60\,\text{V}$$

Using Ohm's law we can find the current through the $4\,\Omega$ resistor:

$$i_{4\,\Omega} = \frac{60\,\text{V}}{4\,\Omega} = 15\,\text{A}$$

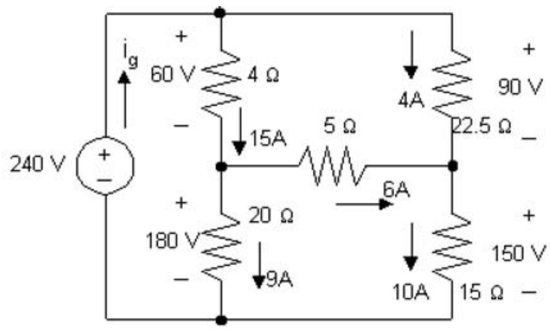
Write a KCL equation at the middle node. Sum the currents entering:

$$15\,\text{A} - 6\,\text{A} - i_{20\,\Omega} = 0 \qquad \text{so} \qquad i_{20\,\Omega} = 15\,\text{A} - 6\,\text{A} = 9\,\text{A}$$

Use Ohm's law to calculate the voltage drop across the $20\,\Omega$ resistor:

$$v_{20\,\Omega} = (20\,\Omega)(9\,\text{A}) = 180\,\text{V}$$

All of the voltages and currents calculated above are shown in the figure below:



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

$p_{4\Omega} = (4)(15)^2 = 900\,\text{W}$ $\qquad p_{20\Omega} = (20)(9)^2 = 1620\,\text{W}$

$p_{5\Omega} = (5)(6)^2 = 180\,\text{W}$ $\qquad p_{22.5\Omega} = (22.5)(4)^2 = 360\,\text{W}$

$p_{15\Omega} = (15)(10)^2 = 1500\,\text{W}$

[b] We can calculate the current in the voltage source, i_g by writing a KCL equation at the top middle node:

$i_g = 15\,\text{A} + 4\,\text{A} = 19\,\text{A}$

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

$p_g = -240(19) = -4560\,\text{W}$ $\quad$ thus $\quad$ p_g (supplied) $= 4560\,\text{W}$

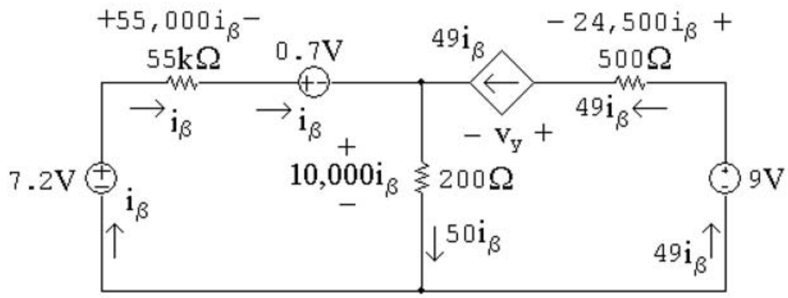
[c] $\sum P_{\text{dis}} = 900 + 1620 + 180 + 360 + 1500 = 4560\,\text{W}$
Therefore,

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

P 2.29 First note that we know the current through all elements in the circuit except the $200\,\Omega$ resistor (the current in the three elements to the left of the $200\,\Omega$ resistor is i_β; the current in the three elements to the right of the $200\,\Omega$ resistor is $49i_\beta$). To find the current in the $200\,\Omega$ resistor, write a KCL equation at the top node:

$$i_\beta + 49i_\beta = i_{200\,\Omega} = 50i_\beta$$

We can then use Ohm's law to find the voltages across each resistor in terms of i_β. The results are shown in the figure below:



[a] To find i_β, write a KVL equation around the left-hand loop, summing voltages in a clockwise direction starting below the 7.2V source:

$$-7.2\,\text{V} + 55{,}000i_1 + 0.7\,\text{V} + 10{,}000i_\beta = 0$$

Solving for i_β

$$55{,}000i_\beta + 10{,}000i_\beta = 6.5\,\text{V} \qquad \text{so} \qquad 65{,}000i_\beta = 6.5\,\text{V}$$

Thus,

$$i_\beta = \frac{6.5}{65{,}000} = 100\,\mu\text{A}$$

Now that we have the value of i_β, we can calculate the voltage for each component except the dependent source. Then we can write a KVL equation for the right-hand loop to find the voltage v_y of the dependent source. Sum the voltages in the clockwise direction, starting to the left of the dependent source:

$$-v_y - 24{,}500i_\beta + 9\,\text{V} - 10{,}000i_\beta = 0$$

Thus,

$$v_y = 9\,\text{V} - 34{,}500i_\beta = 9\,\text{V} - 34{,}500(100 \times 10^{-6}) = 9\,\text{V} - 3.45\,\text{V} = 5.55\,\text{V}$$

[b] We now know the values of voltage and current for every circuit element. Let's construct a power table:

Element	**Current (μA)**	**Voltage (V)**	**Power Equation**	**Power (μW)**
7.2 V	100	7.2	$p = -vi$	-720
55 kΩ	100	5.5	$p = Ri^2$	550
0.7 V	100	0.7	$p = vi$	70
200 Ω	5000	1	$p = Ri^2$	5000
Dep. source	4900	5.55	$p = vi$	27,195
500 Ω	4900	2.45	$p = Ri^2$	12,005
9 V	4900	9	$p = -vi$	$-44{,}100$

The total power generated in the circuit is the sum of the negative power values in the power table:

$$-720\,\mu\text{W} + -44{,}100\,\mu\text{W} = -44{,}820\,\mu\text{W}$$

Thus, the total power generated in the circuit is $44{,}820\,\mu$W. The total power absorbed in the circuit is the sum of the positive power values in the power table:

$$550\,\mu\text{W} + 70\,\mu\text{W} + 5000\,\mu\text{W} + 27{,}195\,\mu\text{W} + 12{,}005\,\mu\text{W} = 44{,}820\,\mu\text{W}$$

Thus, the total power absorbed in the circuit is $44{,}820\,\mu$W and the power in the circuit balances.