Problem 1

The energy supplied by the battery is the energy consumed by the lights.

$$E_{\text{supplied}} = E_{\text{consumed}} \quad \rightarrow \quad Q\Delta V = Pt \quad \rightarrow$$

$$t = \frac{Q\Delta V}{P} = \frac{(85\,\text{A}\cdot\text{h})(3600\,\text{s/h})(12\,\text{V})}{92\,\text{W}} = 39913\,\text{s}\left(\frac{1\,\text{h}}{3600\,\text{s}}\right) = 11.09\,\text{h} \approx \boxed{11\,\text{h}}$$

Alternative solution:

$$P = IV \quad \therefore \quad I = \frac{P}{V} = \frac{92\,\text{W}}{12\,\text{V}} = 7.67\,\text{A}$$

$$I \cdot t = 85\,\text{A}\cdot\text{h} = 85 \times 3600\ (\text{c})$$

$$t = \frac{85 \times 3600}{7.67} = 39895\ (\text{s})$$

$$= 11\ (\text{h})$$

Problem 2

Use Eqs. 25-3 and 25-7b.

$$R = \rho\frac{\ell}{A} = \rho\frac{\ell}{\pi r^2} = \frac{4\rho\ell}{\pi d^2} \ ; \ P = \frac{V^2}{R} = \frac{V^2}{\dfrac{4\rho\ell}{\pi d^2}} \quad \rightarrow$$

$$\ell = \frac{V^2\pi d^2}{4\rho P} = \frac{(1.5\,\text{V})^2\,\pi\left(5.0\times10^{-4}\,\text{m}\right)^2}{4\left(1.68\times10^{-8}\,\Omega\cdot\text{m}\right)(15\,\text{W})} = 1.753\,\text{m} \approx \boxed{1.8\,\text{m}}$$

If the voltage increases by a factor of 6 without the resistance changing, the power will increase by factor of 36. The blanket would theoretically be able to deliver 540 W of power, which might mak the material catch on fire or burn the occupant.

Problem 3

Eq. 25-3 can be used. The area to be used is the cross-sectional area of the pipe.

$$R = \frac{\rho\ell}{A} = \frac{\rho\ell}{\pi\left(r_{\text{outside}}^2 - r_{\text{inside}}^2\right)} = \frac{\left(1.68\times10^{-8}\,\Omega\cdot\text{m}\right)(10.0\,\text{m})}{\pi\left[\left(2.50\times10^{-2}\,\text{m}\right)^2 - \left(1.50\times10^{-2}\,\text{m}\right)^2\right]} = \boxed{1.34\times10^{-4}\,\Omega}$$

Problem 4

The volume of the wire remains constant as it is stretched. The cross-sectional area of the wire changes uniformly as it stretches.

Solve: The resistance of the wire before it is stretched is

$$R = \frac{\rho L}{A} = \frac{\rho L^2}{AL} = \frac{\rho L^2}{V}.$$

The volume V remains constant as the wire is stretched. After stretching, the resistance is

$$R' = \frac{\rho L'^2}{V}.$$

Taking the ratio of these two equations and using the fact that ρ is a property of the material and therefore does not change,

$$\frac{R}{R'} = \frac{L^2}{L'^2} = \frac{L^2}{(2L)^2} = \frac{1}{4} \Rightarrow R' = 4R$$

The wire's resistance is $4R$.

Assess: Stretching a wire increases the one dimension of length but decreases the two dimensions of cross-sectional area, so the resistance increases.

Problem 5

$\boxed{25.}$ (*a*) Note that adding resistors in series always results in a larger resistance, and adding resistors in parallel always results in a smaller resistance. Closing the switch adds another resistor in parallel with R_3 and R_4, which lowers the net resistance of the parallel portion of the circuit, and thus lowers the equivalent resistance of the circuit. That means that more current will be delivered by the battery. Since R_1 is in series with the battery, its voltage will increase. Because of that increase, the voltage across R_3 and R_4 must decrease so that the total voltage drops around the loop are equal to the battery voltage. Since there was no voltage across R_2 until the switch was closed, its voltage will increase. To summarize:

$$\boxed{V_1 \text{ and } V_2 \text{ increase ; } V_3 \text{ and } V_4 \text{ decrease}}$$

(*b*) By Ohm's law, the current is proportional to the voltage for a fixed resistance. Thus

$$\boxed{I_1 \text{ and } I_2 \text{ increase ; } I_3 \text{ and } I_4 \text{ decrease}}$$

(*c*) Since the battery voltage does not change and the current delivered by the battery increases, the power delivered by the battery, found by multiplying the voltage of the battery by the current delivered, $\boxed{\text{increases}}$.

(*d*) Before the switch is closed, the equivalent resistance is R_3 and R_4 in parallel, combined with R_1 in series.

$$R_{eq} = R_1 + \left(\frac{1}{R_3} + \frac{1}{R_4}\right)^{-1} = 125\,\Omega + \left(\frac{2}{125\,\Omega}\right)^{-1} = 187.5\,\Omega$$

The current delivered by the battery is the same as the current through R_1.

$$I_{total} = \frac{V_{battery}}{R_{eq}} = \frac{22.0\text{ V}}{187.5\,\Omega} = 0.1173\text{ A} = I_1$$

The voltage across R_1 is found by Ohm's law.

$$V_1 = IR_1 = (0.1173\,\text{A})(125\,\Omega) = 14.66\,\text{V}$$

The voltage across the parallel resistors is the battery voltage less the voltage across R_1.

$$V_p = V_{\text{battery}} - V_1 = 22.0\,\text{V} - 14.66\,\text{V} = 7.34\,\text{V}$$

The current through each of the parallel resistors is found from Ohm's law.

$$I_3 = \frac{V_p}{R_2} = \frac{7.34\,\text{V}}{125\,\Omega} = 0.0587\,\text{A} = I_4$$

Notice that the current through each of the parallel resistors is half of the total current, within the limits of significant figures. The currents before closing the switch are as follows.

$$\boxed{I_1 = 0.117\,\text{A} \quad I_3 = I_4 = 0.059\,\text{A}}$$

After the switch is closed, the equivalent resistance is R_2, R_3, and R_4 in parallel, combined with R_1 in series. Do a similar analysis.

$$R_{\text{eq}} = R_1 + \left(\frac{1}{R_2} + \frac{1}{R_3} + \frac{1}{R_4}\right)^{-1} = 125\,\Omega + \left(\frac{3}{125\,\Omega}\right)^{-1} = 166.7\,\Omega$$

$$I_{\text{total}} = \frac{V_{\text{battery}}}{R_{\text{eq}}} = \frac{22.0\,\text{V}}{166.7\,\Omega} = 0.1320\,\text{A} = I_1 \quad V_1 = IR_1 = (0.1320\,\text{A})(125\,\Omega) = 16.5\,\text{V}$$

$$V_p = V_{\text{battery}} - V_1 = 22.0\,\text{V} - 16.5\,\text{V} = 5.5\,\text{V} \quad I_2 = \frac{V_p}{R_2} = \frac{5.5\,\text{V}}{125\,\Omega} = 0.044\,\text{A} = I_3 = I_4$$

Notice that the current through each of the parallel resistors is one third of the total current, within the limits of significant figures. The currents after closing the switch are as follows.

$$\boxed{I_1 = 0.132\,\text{A} \quad I_2 = I_3 = I_4 = 0.044\,\text{A}}$$

$\boxed{\text{Yes}}$, the predictions made in part (*b*) are all confirmed.

Problem 6

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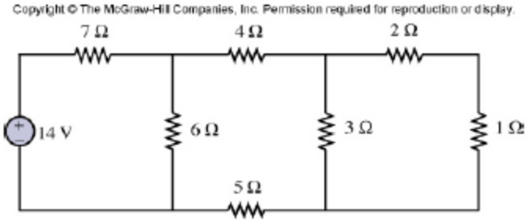


Solution:

Known quantities:

Circuits of Figure 2.48.

Find:

a) Equivalent resistance
b) Power delivered.

Analysis:

(a)

$$2\Omega + 1\Omega = 3\Omega$$

$$3\Omega \| 3\Omega = 1.5\Omega$$

$$4\Omega + 1.5\Omega + 5\Omega = 10.5\Omega$$

$$10.5\Omega \| 6\Omega = 3.818\Omega$$

$$R_{eq} = 3.818\Omega + 7\Omega = 10.818\Omega$$

(b)

$$I = \frac{14\text{V}}{10.818\Omega} = 1.29\text{A}$$

$$P = (14\text{V})(1.29\text{A}) = 18.06\text{W}$$

Problem 7

79. The current in the circuit can be found from the resistance and the power dissipated. Then the product of that current and the equivalent resistance is equal to the battery voltage.

$$P = I^2R \rightarrow I = \sqrt{\frac{P_{33}}{R_{33}}} = \sqrt{\frac{0.80\,\mathrm{W}}{33\,\Omega}} = 0.1557\,\mathrm{A}$$

$$R_{eq} = 33\,\Omega + \left(\frac{1}{68\,\Omega} + \frac{1}{75\,\Omega}\right)^{-1} = 68.66\,\Omega \quad V = IR_{eq} = (0.1557\,\mathrm{A})(68.66\,\Omega) = 10.69\,\mathrm{V} \approx \boxed{11\,\mathrm{V}}$$

Problem 8

80. If the switches are both open, then the circuit is a simple series circuit. Use Kirchhoff's loop rule to find the current in that case.

$$6.0\,\mathrm{V} - I(50\,\Omega + 20\,\Omega + 10\,\Omega) = 0 \rightarrow I = 6.0\,\mathrm{V}/80\,\Omega = 0.075\,\mathrm{A}$$

If the switches are both closed, the 20-Ω resistor is in parallel with *R*. Apply Kirchhoff's loop rule t the outer loop of the circuit, with the 20-Ω resistor having the current found previously.

$$6.0\,\mathrm{V} - I(50\,\Omega) - (0.075\,\mathrm{A})(20\,\Omega) = 0 \rightarrow I = \frac{6.0\,\mathrm{V} - (0.075\,\mathrm{A})(20\,\Omega)}{50\,\Omega} = 0.090\,\mathrm{A}$$

This is the current in the parallel combination. Since 0.075 A is in the 20-Ω resistor, 0.015 A must be in *R*. The voltage drops across *R* and the 20-Ω resistor are the same since they are in parallel.

$$V_{20} = V_R \rightarrow I_{20}R_{20} = I_R R \rightarrow R = R_{20}\frac{I_{20}}{I_R} = (20\,\Omega)\frac{0.075\,\mathrm{A}}{0.015\,\mathrm{A}} = \boxed{100\,\Omega}$$

Problem 9

82. (*a*) The 12-Ω and the 25-Ω resistors are in parallel, with a net resistance $R_{1\text{-}2}$ as follows.

$$R_{1\text{-}2} = \left(\frac{1}{12\,\Omega} + \frac{1}{25\,\Omega}\right)^{-1} = 8.108\,\Omega$$

$R_{1\text{-}2}$ is in series with the 4.5-Ω resistor, for a net resistance $R_{1\text{-}2\text{-}3}$ as follows.

$$R_{1\text{-}2\text{-}3} = 4.5\,\Omega + 8.108\,\Omega = 12.608\,\Omega$$

That net resistance is in parallel with the 18-Ω resistor, for a final equivalent resistance as follows.

$$R_{\text{eq}} = \left(\frac{1}{12.608\,\Omega} + \frac{1}{18\,\Omega}\right)^{-1} = 7.415\,\Omega \approx \boxed{7.4\,\Omega}$$

(*b*) Find the current in the 18-Ω resistor by using Kirchhoff's loop rule for the loop containing the battery and the 18-Ω resistor.

$$\mathscr{E} - I_{18}R_{18} = 0 \;\rightarrow\; I_{18} = \frac{\mathscr{E}}{R_{18}} = \frac{6.0\,\text{V}}{18\,\Omega} = \boxed{0.33\,\text{A}}$$

(*c*) Find the current in $R_{1\text{-}2}$ and the 4.5-Ω resistor by using Kirchhoff's loop rule for the outer loop containing the battery and the resistors $R_{1\text{-}2}$ and the 4.5-Ω resistor.

$$\mathscr{E} - I_{1\text{-}2}R_{1\text{-}2} - I_{1\text{-}2}R_{4.5} = 0 \;\rightarrow\; I_{1\text{-}2} = \frac{\mathcal{E}}{R_{1\text{-}2} + R_{4.5}} = \frac{6.0\,\text{V}}{12.608\,\Omega} = 0.4759\,\text{A}$$

This current divides to go through the 12-Ω and 25-Ω resistors in such a way that the voltage drop across each of them is the same. Use that to find the current in the 12-Ω resistor.

$$I_{1\text{-}2} = I_{12} + I_{25} \;\rightarrow\; I_{25} = I_{1\text{-}2} - I_{12}$$

$$V_{R_{12}} = V_{R_{25}} \rightarrow I_{12}R_{12} = I_{25}R_{25} = \left(I_{1\text{-}2} - I_{12}\right)R_{25} \;\rightarrow$$

$$I_{12} = I_{1\text{-}2}\frac{R_{25}}{\left(R_{12} + R_{25}\right)} = (0.4759\,\text{A})\frac{25\,\Omega}{37\,\Omega} = \boxed{0.32\,\text{A}}$$

(*d*) The current in the 4.5-Ω resistor was found above to be $I_{1\text{-}2} = 0.4759\,\text{A}$. Find the power accordingly.

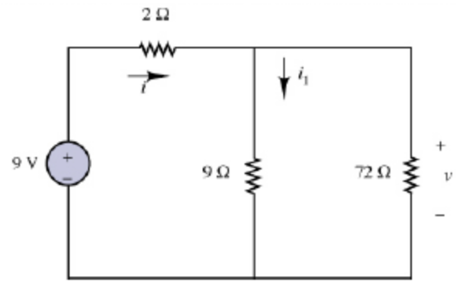
$$P_{4.5} = I_{1\text{-}2}^2 R_{4.5} = (0.4759\,\text{A})^2(4.5\,\Omega) = 1.019\,\text{W} \approx \boxed{1.0\,\text{W}}$$

Problem 10

Solution:

Known quantities:

Circuits of Figure 2.44.



Find:

Equivalent resistance and i, i_1, v .

Analysis:

$R_{EQ} = 2 + (9 \parallel 72) = 10\ \Omega$. Therefore,

$$i = \frac{9}{10} = 0.9\ \text{A}$$

By the current divider rule:

$$i_1 = \frac{72}{72+9}(0.9) = \frac{72}{81}(0.9) = 0.8\ \text{A}\ .$$

Also, since the 9 Ωand 72 Ω resistors are in parallel, we can conclude that

$$v = 9 i_1 = 7.2\ \text{V}$$