\[ I = 25000 \text{ A} \]
\[ \Delta t = 40 \mu s = 40 \times 10^{-6} \text{ s} \]

\[ I = \frac{\Delta q}{\Delta t} \]

\[ \Delta q = I \Delta t \]

\[ \Delta q = (25000 \text{ A})(40 \times 10^{-6} \text{ s}) \]

\[ \Delta q = 1 \text{ C} \]

\[ I = 5 \text{ A} \]

\[ P = 10 \text{ watt} \]

\[ \Delta t = 4 \text{ min} = 240 \text{ s} \]

a) \[ I = \frac{\Delta q}{\Delta t} \]

\[ \Delta q = I \Delta t \]

\[ \Delta q = (5 \text{ A})(240 \text{ s}) \]

\[ \Delta q = 1200 \text{ C} \]

b) \[ 1200 \text{ C} \left( \frac{1 \text{ e}^-}{1.602 \times 10^{19} \text{ C}} \right) = 7.5 \times 10^{21} \text{ electrons} \]

\[ P = 1450 \text{ watts} \]

\[ \Delta V = 120 \text{ V} \]

\[ R = ? \]

\[ \text{Solve} \]

\[ P = I \Delta V \]

\[ I = \frac{P}{\Delta V} = \frac{1450}{120} = 12.1 \text{ A} \]

\[ \Delta V = IR \]

\[ R = \frac{\Delta V}{I} = \frac{120}{12.1} = 9.92 \Omega \]
\[ r = \frac{6\text{mm}}{2} = 3\text{mm} = 0.003\text{m} \]

\[ \Delta V = 2.3\text{V (end to end)} \]

\[ R = 15 \text{k}\Omega = 15000\Omega \]

\[ \begin{align*}
0) & \quad \Delta V = IR \\
& \quad I = \frac{\Delta V}{R} = \frac{2.3}{15000} = 0.0015\text{A} = 1.5\text{mA} \\
6) & \quad R = \frac{pL}{A} \\
& \quad p = \frac{RA}{L} = \frac{R(r^2)}{L} = \frac{15000\Omega \pi (0.003)^2\text{m}^2}{4\text{m}} = 0.112\Omega \text{m} \\
5) & \quad r = \frac{0.6\text{mm}}{2} = 0.3\text{mm} = 3 \times 10^{-4}\text{m} \\
& \quad \Delta V = 1.5\text{V} \\
& \quad I = 0.5\text{A} \\
& \quad p = 1.7 \times 10^{-8} \text{J}/\text{m} \text{ for copper (Table 22.1)} \]

\[ \begin{align*}
& \quad \Delta V = IR \\
& \quad R = \frac{\Delta V}{I} = \frac{1.5}{0.5} = 3\Omega \\
& \quad R = \frac{pL}{A} \\
& \quad L = \frac{RA}{p} = \frac{R(r^2)}{p} = \frac{1.7 \times 10^{-8} \text{J}/\text{m}}{1.7 \times 10^{-8} \text{J}/\text{m} \text{m}} = 50\text{m} \\
\end{align*} \]

Note: copper wires have little resistance. 50m needed to get only 3\Omega of resistance.
a) Battery

Terminal voltage = 21.2V

\[ \Delta V = E - IR \]

\[ 21.2 = 24 - 4I \]

\[ 4I = 2.8 \]

\[ I = 0.7 \text{ A} \]

\[ R = \frac{E - \Delta V}{I} = \frac{24 - 21.2}{0.7} = 0.72 \Omega \]

b) Circuit is equivalent to

\[ \Delta V = IR \]

\[ R = \frac{\Delta V}{I} = \frac{21.2}{0.7} = 3.03 \Omega \]

\[ R = 3.3 \Omega \]

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\[ \frac{\sqrt{2}}{4} \]

\[ 2.5 \Omega \]

\[ (\sqrt{2})^2 + 2.5 \]

\[ = 2.5 \Omega \]

\[ \frac{\sqrt{2}}{4} + 2.5 \]

\[ = 4.5 \Omega \]

\[ R_{eq} = 4.5 \Omega \]
\[ R_{eq} = \frac{1 + 1 + 1 + 1}{4} = 0.25 \ \text{k}\Omega \]

\[ R_{eq} = 1 + (\frac{1}{4} + \frac{1}{4})^4 = 0.582 \]

\[ R_{eq} = 1 + (\frac{1}{4} + \frac{1}{4})^4 = 1.332 \]

\[ R_{eq} = R_{abcd} = 5 + 1.672 = 6.672 \]

\[ V = IR \]

\[ I = \frac{10V}{6.672} \]

\[ I = 1.5A \]  Total current for circuit, leaving the battery.
a) The total current \(1.5\text{A}\) travels through resistor a)

b) Since \(R_b = R_c = R_d\) are all in parallel and the same value they each get \(\frac{1}{3}\) of the total current, \(\frac{1.5\text{A}}{3} = 0.5\text{A}\)

I'll work the algebra since resistors aren't always equal values,

\[\begin{align*}
\Delta V_b &= 1.5\times R_b \\
\Delta V_c &= 1.5\times (S) \\
\Delta V_d &= 1.5\times (S) \\
\end{align*}\]

10V given by battery
Ra removes 7.5 V
Each of \(\Delta V_b = \Delta V_c = \Delta V_d\)
Thus must be \(10 - 7.5 = 2.5\text{V}\)

c) Found above, \(\Delta V_a = I_aR_a = 1.5\times (S) = 7.5\text{V}\)

d) Explained above, \(\Delta V_d = 10 - 7.5 = 2.5\text{V}\)

The 4\(\Omega\) removes 6\(\Omega\) and each of the 1 \(\Omega\) and 1\(\Omega\) remove the other 6\(\Omega\).
current splits equally and each parallel branch removes a total of 12V

\[
\begin{align*}
\frac{4+4}{3+5} &= \frac{8}{12} = \frac{2}{3} \\
\frac{12}{2} &= 6 \\
\Delta V &= IR \\
I &= \frac{\Delta V}{R} = \frac{12}{4} = 3A \\
\text{I'll now work back upwards through the circuit in green.}
\end{align*}
\]

**GREEN WAS WORKED UPWARD AFTER THE BLACK**

(a) \(\Delta V = 7.5V\) for 5Ω resistor
(b) For the 6Ω resistor, \(I = 1A\) and \(\Delta V = 6V\)

\[P = I\Delta V\]
\[P = (1)(7.5)(651C)\]
\[P = 66\text{ watts}\]

Using Kirchoff's Rules and assigning directions for \(I_1, I_2, I_3\) as indicated
1. \( I_1 + I_2 = I_3 \)  
(current at junction A)

2. \( 2 - I_1 + I_2 - 4 + I_2 = 0 \)  
(outer loop clockwise starting at point B)

3. \( 2 - I_1 - 2I_3 - 4 = 0 \)  
(left loop clockwise starting at B)

Solving 3 equations, 3 unknowns

Step 1: solve \( @ \) for \( I_2 \)
\[-2 - I_1 + 2I_2 = 0\]
\[2I_2 = 2 + I_1\]
\[I_2 = 1 + \frac{1}{2} I_1\]

Step 2: solve \( @ \) for \( I_3 \)
\[-2 - I_1 - 2I_3 = 0\]
\[2I_3 = -2 - I_1\]
\[I_3 = -1 - \frac{1}{2} I_1\]

Step 3: Plug step 1 + 2 into eq'n \( @ \)
\[I_1 + I_2 = I_3\]
\[I_1 + (1 + \frac{1}{2} I_1) = (-1 - \frac{1}{2} I_1)\]
\[2I_1 = -1 - 1\]
\[2I_1 = -2\]
\[I_1 = -1A\]

Step 4: Plug \( I_1 = -1A \) into steps 1 + 2
\[I_2 = 1 + \frac{1}{2} I_1\]
\[I_3 = -1 - \frac{1}{2} I_1\]
\[I_2 = 1 + \frac{1}{2} (-1)\]
\[I_3 = -1 - \frac{1}{2} (-1)\]
\[I_2 = 0.5A\]
\[I_3 = -0.5A\]

I chose directions for \( I_1 \) and \( I_3 \) wrong as indicated by the negative signs.

\[I_1 = 1A\]
\[I_2 = 0.5A\]
\[I_3 = -0.5A\]
a) \( t = RC = (1.4 \times 10^6 \Omega \times 1.8 \times 10^{-6} \text{s}) = 2.52 \text{s} \)

b) \( Q_{\text{max}} = CV = (1.8 \times 10^{-6} \text{ F})(12 \text{ V}) = 2.16 \times 10^{-5} \text{ C} = 21.6 \mu \text{C} \)

c) \( Q = CV (1 - e^{-t/\tau}) \)
\( Q_{\text{max}} = CV (1 - e^{-t/\tau}) \)
\( 16 \mu \text{C} = 21.6 \mu \text{C} (1 - e^{-t/2.52}) \)
\( 1 - e^{-t/2.52} = \frac{16}{21.6} = 0.74 \)
\( e^{-t/2.52} = 1 - 0.74 = 0.26 \)
\( \frac{-t}{2.52} = \ln(0.26) \)
\( t = -2.52 \ln(0.26) \)
\( t = 3.4 \text{s} \)

L3

\( \Delta V = 100 \text{ V} \)

At \( t = 10 \text{ sec} \), \( \Delta V = 1 \text{ V} \)

a) \( \tau = \frac{\Delta V}{\Delta V_0 e^{-t/\tau}} \)
\( 1 = 100 e^{-10/\tau} \)
\( 0.01 = e^{-10/\tau} \)
\( -10/\tau = \ln(0.01) \)
\( \tau = -\frac{10}{\ln(0.01)} \)
\( \tau = 2.17 \text{s} \)

b) \( \Delta V = \frac{\Delta V_0 e^{-t/\tau}}{2} \)
\( \Delta V = 100 e^{-17/2.17} \)
\( \Delta V = 0.04 \text{ V} \)

pretty much discharged

c) \( \tau = ? \) when \( \Delta V = \frac{\Delta V_0}{2} \)
\( \Delta V_0 = \Delta V_0 e^{-t/\tau} \)
\( \Delta V = 100 e^{-17/2.17} \)
\( \Delta V = 0.04 \text{ V} \)
\( \frac{-t}{2.17} = \ln(0.5) \)
\( t = -2.17 \ln(0.5) \)
\( t = 1.55 \text{s} \)