Consider a series $RC$ circuit as in Figure P28.34 for which $R = 1.00 \, \text{M} \Omega$, $C = 5.00 \, \mu \text{F}$, and $\mathcal{E} = 30.0 \, \text{V}$. Find (a) the time constant of the circuit and (b) the maximum charge on the capacitor after the switch is thrown closed. (c) Find the current in the resistor 10.0 s after the switch is closed.

**Figure P28.34**
Problems 34, 63, and 64.

1. $RC = (1 \times 10^{-6} \Omega)(5 \times 10^{-6} \text{F}) = 5 \, \text{s}$
2. $Q = CE = (5 \times 10^{-6} \text{C})(30 \text{V}) = 150 \mu \text{C}$
3. $I(t) = \frac{\mathcal{E}}{R} e^{-\frac{t}{RC}} = \left(\frac{30 \text{V}}{1 \times 10^{-6} \Omega}\right) e^{-\frac{10 \text{s}}{5 \text{s}}} = 14.1 \, \mu \text{A}$
A 10.0-\(\mu\)F capacitor is charged by a 10.0-V battery through a resistance \(R\). The capacitor reaches a potential difference of 4.00 V in a time interval of 3.00 s after charging begins. Find \(R\).

Potential difference across the capacitor:

\[ \Delta V(t) = \Delta V_{\text{max}} \left( 1 - e^{-t/\tau} \right) \]

Remember that \(1/\tau = 1/\sqrt{\omega} \)

\[ 4V = 10V \left[ 1 - e^{-3 \text{sec} / R (10 \times 10^{-5} \text{sec})} \right] \]

\[ e^{-4} = 1 - e^{-3 \times 10^5 \text{sec}/R} \]

\[ 0.6 = e^{-3 \times 10^5 / R} \]

\[ \ln 0.6 = -3 \times 10^5 / R \]

\[ \ln 0.6 = \ln e^{-3 \times 10^5 / R} \]

\[ \ln 0.6 = \frac{-3 \times 10^5}{R} \]

\[ R = \frac{-3 \times 10^5}{\ln(0.6)} = 587 \text{ k\Omega} \]
The circuit in Figure P28.37 has been connected for a long time. (a) What is the potential difference across the capacitor? (b) If the battery is disconnected from the circuit, over what time interval does the capacitor discharge to one-tenth its initial voltage?

After a long time, the capacitor is fully charged.

(a) \[ I_L = \frac{10\text{V}}{5\Omega} = 2\text{A} \]

\[ V_R = \frac{2\text{A}}{2\Omega + 8\Omega} \times 10\text{V} = 2\text{V} \]

\[ I_R = \frac{10\text{V}}{10\Omega} = 1\text{A} \]

\[ V_R = 10\text{V} - (8\Omega \times 1\text{A}) = 2\text{V} \]

\[ \Delta V = V_L - V_R = 8 - 2 = 6\text{V} \]

(b) So now the circuit looks like

\[ R = \left(\frac{1}{5\Omega} + \frac{1}{6\Omega}\right)^{-1} = 3.6\Omega \]

\[ RC = 3.6 \times 10^{-6}\text{S} \]

\[ e^{-t/RC} = \frac{1}{10} \]

\[ t = RC \ln 10 = 8.29\mu\text{s} \]