1. Serway, Problem 28.27

   Solution

   (a) The time constant for an RC circuit is given by $\tau = RC$, thus

$$\begin{aligned}\tau &= RC \\ &= (1.00)(5 \times 10^{-6}) \\ &= \boxed{5\ \mu\text{s}}.\end{aligned}$$

   (b) When fully charged, the capacitor becomes a break in the circuit and the plates will be separated by a potential difference equivalent to the emf of the battery. The charge on the capacitor for this potential difference is

$$\begin{aligned}Q &= C\Delta V \\ &= C\mathcal{E} \\ &= (5 \times 10^{-6})(30) \\ &= \boxed{150\ \mu\text{C}}.\end{aligned}$$

   (c) Immediately after the switch is thrown to a, the capacitor discharges through R. At $t = 10$ s, the current is

$$\begin{aligned}I(10) &= \frac{Q}{\tau}e^{-10/\tau} \\ &= \frac{1.5 \times 10^{-4}}{(5 \times 10^{-6})e^2} \\ &= \boxed{4.1\ \text{A}}.\end{aligned}$$

2. Serway, Problem 28.31

   Solution

   This circuit is known as a Wheatstone bridge. The key to finding the potential difference across the capacitor is to recognize, once again, that when fully charged, the capacitor becomes an open circuit. An equivalent resistance for the circuit may then be found, and then working backwards, individual voltage drops across individual resistors may be determined. The answer is $\boxed{6\ \text{V}}$.

   When the battery is disconnected, the capacitor discharges from positive to negative plate through a parallel combination of series resistors whose equivalent resistance is 3.6 Ω. In the discharge phase, the charge on a capacitor as a function of time is

$$q(t) = Qe^{-t/\tau}.$$

Solving for t we have

$$\begin{aligned} t &= -\tau \ln \frac{q}{Q} \\ &= -(3.6)(1 \times 10^{-6}) \ln 0.1 \\ &= \boxed{8.3\ \mu\text{s}}. \end{aligned}$$

3. Serway, Problem 28.61

Solution

This is a problem for the checklist application of Kirchhoff's Rules:

- Sketch the circuit.
- Choose a direction for the current in each branch of the circuit and label them. Add plus- and minus-signs to indicate the high- and low- potential sides of each resistor, capacitor, and source of emf.
- Replace any combination of resistors in series or parallel with equivalent resistances.
- Apply the junction rule to each junction where the current divides.
- Apply the loop rule to each loop until you obtain as many equations as unknowns.
- Solve the system of equations.
- Check results by assigning $V = 0$ at some point in the circuit and determine potentials around the circuit.

(a) At steady state, the current through both the 12.0 and 15.0 kΩ resistors is $\boxed{0.33\ \text{mA}}$. Since the capacitor is fully charged, there is no current through that loop, and so no current through the 3.00 kΩ resistor.

(b) To satisfy the loop rule, when fully charged, the capacitor must constitute a voltage climb equivalent to the drop across the 15.0 kΩ at 0.33 mA, or $(3.3 \times 10^{-4})(1.5 \times 10^{4}) = 5$ V. The charge is then

$$\begin{aligned} Q &= CV \\ &= (1 \times 10^{-5})(5) \\ &= \boxed{50\ \mu\text{C}}. \end{aligned}$$

(c) During the discharge phase, the current in the 15.0 kΩ resistor is given by

$$\boxed{I(t) = (2.8 \times 10^{-4})e^{-t/0.18}}.$$

(d) The capacitor will discharge to one fifth its original charge in $\boxed{0.29\text{ s}}$, as given by solving for t in

$$q = Qe^{-t/RC}.$$