PHYSQ 126 – Quiz 5 (3 mars 2016) Solution

Problem 21.86

The capacitor in an RC circuit is initially uncharged.

Part A

In terms of R and C, determine the time required for the charge on the capacitor to rise to 50% of its final value.

Express your answer in terms of the variables R and C.

$t =$

Submit My Answers Give Up

Part B

In terms of R and C, determine the time required for the initial current to drop to 10% of its initial value.

Express your answer in terms of the variables R and C.

$t =$

Submit My Answers Give Up

Solutions

86. **Picture the Problem**: A battery, a resistor, and a capacitor form a series *RC* circuit.

Strategy: Equation 21-18 determines the charge on a capacitor in a series *RC* circuit as a function of time. Solve equation 21-18 for the time required to charge the capacitor to 50% of its full charge. Then solve equation 21-19 for the time required for the current to drop to 10% of its initial value.

Solution: 1. (a) Set $q(t) = 0.50 q_{\max} = 0.50\,C\mathcal{E}$ in equation 21-18 and solve for the time t:

$$0.50C\mathcal{E} = C\mathcal{E}\left(1 - e^{-t/RC}\right)$$

$$0.50 = 1 - e^{-t/RC}$$

$$e^{-t/RC} = 1 - 0.50$$

$$-\frac{t}{RC} = \ln 0.50$$

$$t = -RC \ln 0.50 = \boxed{RC \ln 2.0}$$

2. (b) Set $I(t) = 0.10\, I(0) = 0.10\dfrac{\mathcal{E}}{R}$ and solve for t:

$$0.10\frac{\mathcal{E}}{R} = \frac{\mathcal{E}}{R}e^{-t/RC}$$

$$0.10 = e^{-t/RC}$$

$$\ln 0.10 = -\frac{t}{RC} \quad \Rightarrow \quad t = \boxed{RC\ln 10}$$

Insight: When a single time constant has passed, the charge has increased from zero to 63.2% of its final value, and the current has dropped to 36.8% of its initial value.