RC Circuits

Circuits · 7 questions · step-by-step answers at the end

Name: Date: Score: / 7

USEFUL EQUATIONS

$\tau = RC \quad V_C(t) = \varepsilon(1 - e^{-t/\tau}) \quad I(t) = (\varepsilon/R)e^{-t/\tau} \quad V_C(t) = V_0 e^{-t/\tau}$

Questions

Show your working in the space under each question.

1. How long does the same capacitor take to discharge to half its starting voltage?

2. A 10 kΩ resistor and a 200 µF capacitor are connected to a 9.0 V battery through a switch. Find τ, the initial current, V_C after 2.0 s, and the time to reach 90% charge.

3. What fraction of its final charge does a capacitor hold after one time constant?

4. How long does a discharging capacitor take to lose half its charge?

5. Doubling R in an RC circuit has what effect on the final charge and on the charging time?

6. A 10 V battery, a 5 kΩ resistor and an uncharged capacitor are in series. What is the current the instant the switch closes?

7. Show that RC has units of seconds.

Step-by-step answers

RC Circuits

1. $e^{-t/\tau} = ½ \rightarrow t = \tau \ln 2 = 2.0 \times 0.693 \approx$ **1.4 s**.

2. 1. $\tau = RC = (10 \times 10^{3})(200 \times 10^{-6}) =$ **2.0 s**.
2. Initial current: $I_0 = \varepsilon/R = 9.0/10\,000 =$ **0.90 mA**.
3. At $t = 2.0$ s $= \tau$: $V_C = 9.0(1 - e^{-1}) =$ **5.7 V**.
4. 90%: $1 - e^{-t/\tau} = 0.90 \rightarrow t = \tau \ln 10 =$ **4.6 s**.

Answer: τ = 2.0 s, I_0 = 0.90 mA, V_C = 5.7 V, $t_{90\%}$ = 4.6 s

3. $1 - e^{-1} \approx$ **63%**.

4. $t = \tau \ln 2 \approx$ **0.69 RC**.

5. Final charge is **unchanged** ($Q = C\varepsilon$); charging takes **twice as long** ($\tau = RC$).

6. The capacitor acts like a wire: $I = 10/5000 =$ **2 mA**.

7. $\Omega \cdot F = (V/A)(C/V) = C/A = C/(C/s) =$ **s**.