

1) a)

An uncharged capacitor and a resistor are connected in series to a battery as in Figure 28.18. If $\mathcal{E} = 12.0 \text{ V}$, $C = 5.00 \mu\text{F}$, and $R = 8.00 \times 10^5 \Omega$, find the time constant of the circuit, the maximum charge on the capacitor, the maximum current in the circuit, and the charge and current as a function of time.

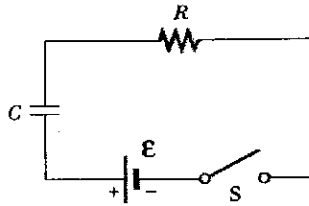


FIGURE 28.18 (Example 28.11) The switch of this series RC circuit is closed at $t = 0$.

$$\tau = RC = (8 \times 10^5 \Omega)(5 \times 10^{-6} \text{ F}) = \underline{4 \text{ s}}$$

$$Q_{\text{max}} = C\mathcal{E} = (5 \times 10^{-6})(12) = \underline{60 \mu\text{C}}$$

$$I_0 = \mathcal{E}/R = 12/8 \times 10^5 = \underline{15 \mu\text{A}}$$

$$Q(t) = 60(1 - e^{-t/4}) \mu\text{C}$$

$$I(t) = 15e^{-t/4} \mu\text{A}$$

b)

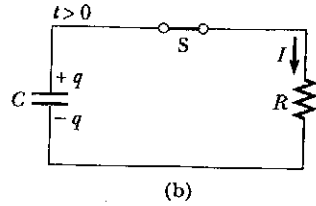
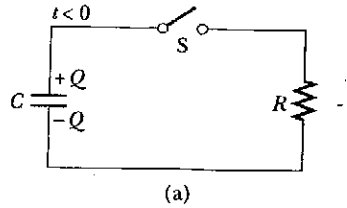
Calculate the charge on the capacitor and current in the circuit after one time constant has elapsed.

After 1 time constant

$$Q = 0.63 Q_0 = \underline{37.9 \mu\text{C}}$$

$$I = 0.37 I_0 = \underline{5.52 \mu\text{A}}$$

2)



a)

Consider a capacitor C being discharged through a resistor R as in Figure 28.17. (a) After how many time constants is the charge on the capacitor one fourth of its initial value?

$$Q = Q_0 e^{-t/RC}$$
$$\text{If } Q = Q_0/4, e^{-t/RC} = 1/4$$
$$-t/RC = \ln(1/4)$$
$$\boxed{t = 1.39 RC}$$

b)

(b) The energy stored in the capacitor decreases with time as it discharges. After how many time constants is this stored energy one fourth of its initial value?

$$U = \frac{Q^2}{2C}$$
$$U(t) = \frac{Q^2(t)}{2C} = \frac{Q_0^2}{2C} e^{-2t/RC} = U_0 e^{-2t/RC}$$

U_0 → initial stored energy

$$\text{If } U = U_0/4 \Rightarrow t = \frac{1}{2} RC \ln 4 = \underline{\underline{0.693 RC}}$$

c)

After how many time constants is the current in the RC circuit one half of its initial value?

$$I = I_0 e^{-t/RC}$$
$$\text{If } I = I_0/2 = I_0 e^{-t/RC}$$
$$\Rightarrow -t/RC = \ln 1/2 \Rightarrow t = \underline{\underline{0.693 RC}}$$