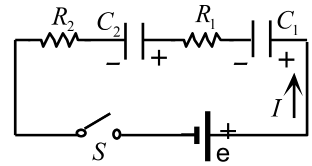
Problem 1

45. The current for a capacitor-charging circuit is given by Eq. 26-8, with R the equivalent series resistance and C the equivalent series capacitance.



$$I = \frac{\text{e}}{R_{\text{eq}}} e^{-\left(\frac{t}{R_{\text{eq}} C_{\text{eq}}}\right)} \rightarrow$$

$$t = -R_{\text{eq}} C_{\text{eq}} \ln\left(\frac{IR_{\text{eq}}}{\text{e}}\right) = -\left(R_1 + R_2\right)\left(\frac{C_1 C_2}{C_1 + C_2}\right) \ln\left[\frac{I\left(R_1 + R_2\right)}{\text{e}}\right]$$

$$= -\left(4400\,\Omega\right)\left[\frac{\left(3.8\times10^{-6}\,\text{F}\right)^2}{7.6\times10^{-6}\,\text{F}}\right] \ln\left[\frac{\left(1.50\times10^{-3}\,\text{A}\right)\left(4400\,\Omega\right)}{\left(12.0\,\text{V}\right)}\right] = \boxed{5.0\times10^{-3}\,\text{s}}$$

Problem 2

48. The voltage of the discharging capacitor is given by $V_C = V_0 e^{-t/RC}$. The capacitor voltage is to be $0.0010V_0$.

$$V_C = V_0 e^{-t/RC} \rightarrow 0.0010V_0 = V_0 e^{-t/RC} \rightarrow 0.0010 = e^{-t/RC} \rightarrow \ln\left(0.010\right) = -\frac{t}{RC} \rightarrow$$

$$t = -RC\ln\left(0.010\right) = -\left(8.7\times10^3\,\Omega\right)\left(3.0\times10^{-6}\,\text{F}\right)\ln\left(0.0010\right) = \boxed{0.18\,\text{s}}$$

Problem 3

86. (*a*) In normal operation, the capacitor is fully charged by the power supply, and so the capacitor voltage is the same as the power supply voltage, and there will be no current through the resistor. If there is an interruption, the capacitor voltage will decrease exponentially – it will discharge. We want the voltage across the capacitor to be at 75% of the full voltage after 0.20 s. Use Eq. 26-9b for the discharging capacitor.

$$V = V_0 e^{-t/RC} \;;\; 0.75V_0 = V_0 e^{-(0.20\,\text{s})/RC} \rightarrow 0.75 = e^{-(0.20\,\text{s})/RC} \rightarrow$$

$$R = \frac{-\left(0.20\,\text{s}\right)}{C\ln\left(0.75\right)} = \frac{-\left(0.20\,\text{s}\right)}{\left(8.5\times10^{-6}\,\text{F}\right)\ln\left(0.75\right)} = 81790\,\Omega \approx \boxed{82\,\text{k}\Omega}$$

(*b*) When the power supply is functioning normally, there is no voltage across the resistor, so the device should NOT be connected between terminals a and b. If the power supply is not functioning normally, there will be a larger voltage across the capacitor than across the capacitor–resistor combination, since some current might be present. This current would result in a voltage drop across the resistor. To have the highest voltage in case of a power supply failure, the device should be connected between terminals $\boxed{\text{b and c}}$.

Problem 4

90. (*a*) The time constant of the *RC* circuit is given by Eq. 26-7.

$$\tau = RC = (33.0\ \text{k}\Omega)(4.00\ \mu\text{F}) = 132\ \text{ms}$$

During the charging cycle, the charge and the voltage on the capacitor increases exponentially as in Eq. 26-6b. We solve this equation for the time it takes the circuit to reach 90.0 V.

$$V = \mathcal{E}\left(1 - e^{-t/\tau}\right) \rightarrow t = -\tau \ln\left(1 - \frac{V}{\mathcal{E}}\right) = -(132\ \text{ms})\ln\left(1 - \frac{90.0\ \text{V}}{100.0\ \text{V}}\right) = \boxed{304\ \text{ms}}$$

(*b*) When the neon bulb starts conducting, the voltage on the capacitor drops quickly to 65.0 V and then starts charging. We can find the recharging time by first finding the time for the capacitor to reach 65.0 V, and then subtract that time from the time required to reach 90.0 V.

$$t = -\tau \ln\left(1 - \frac{V}{\mathcal{E}}\right) = -(132\ \text{ms})\ln\left(1 - \frac{65.0\ \text{V}}{100.0\ \text{V}}\right) = 139\ \text{ms}$$

$$\Delta t = 304\ \text{ms} - 139\ \text{ms} = 165\ \text{ms}\ \ ;\ \ t_2 = 304\,\text{ms} + 165\,\text{ms} = \boxed{469\,\text{ms}}$$

(*c*) The spreadsheet used for this problem can be found on the Media Manager, with filename "PSE4_ISM_CH26.XLS," on tab "Problem 26.90c."