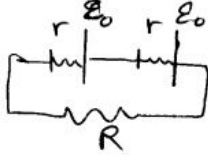


Key Pink

8. (10 pts) A flashlight bulb is powered by two 1.5 V batteries in series, each with internal resistance 0.2 Ω. The batteries each lose chemical energy at the rate of 3.6 W. Determine the resistance of the lightbulb.



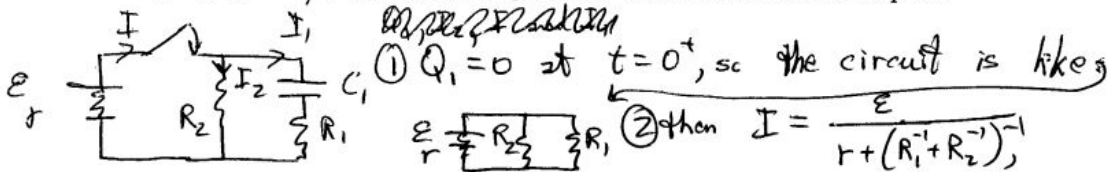
$$\mathcal{E}_0 I = P, \text{ so } I = \frac{P}{\mathcal{E}_0} = \frac{3.6}{1.5} = 2.4 \text{ A}$$

$$\text{But } I = \frac{2\mathcal{E}_0}{2r + R}, \text{ so } R = \frac{2\mathcal{E}_0}{I} - 2r,$$

$$\text{or } R = \frac{3}{2.4} - 0.4 = 1.25 - 0.4 = 0.85 \Omega$$

9. The capacitor is uncharged initially. The switch is then closed at $t = 0$. Let $\mathcal{E} = 6 \text{ V}$, $r = 4 \Omega$, $R_1 = 12 \Omega$, $R_2 = 24 \Omega$, $C_1 = 5 \mu\text{F}$.

- a. (10 pts) Find I , Q_1 , I_1 , and I_2 just after the switch is closed. Explain.



① $Q_1 = 0$ at $t = 0^+$, so the circuit is like

$$\frac{\mathcal{E}}{r + (R_1^{-1} + R_2^{-1})^{-1}}$$

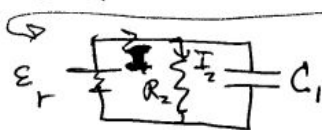
$$\text{which gives } I = \frac{6}{4 + (\frac{1}{12} + \frac{1}{24})^{-1}} = \frac{6}{4 + 8} = 0.5 \text{ A}$$

$$\Delta V_2 = \Delta V_1 = I(\frac{1}{12} + \frac{1}{24})^{-1} = 0.5(8) = 4 \text{ V}$$

$$I_1 = \frac{\Delta V_1}{R_1} = 0.333 \text{ A}, \quad I_2 = \frac{\Delta V_2}{R_2} = 0.167 \text{ A}, \quad (I_1 + I_2 = I)$$

- b. (10 pts) Find I , Q_1 , I_1 , and I_2 a long time after the switch is closed. Explain.

① $Q_1 = \text{const}$ after a long time, so $I_1 = 0$, so circuit looks like



$$\text{① } I = I_2 = \frac{\mathcal{E}}{r + R_2} = \frac{6}{4 + 24} = 0.214 \text{ A}$$

$$\text{② } \Delta V_2 = I_2 R_2 = \frac{Q_1}{C_1} \Rightarrow 5.14 \text{ V} \quad (\mu = 10^{-6})$$

$$\text{so } Q_1 = C_1 (I_2 R_2) = 25.7 \mu\text{C}$$

- c. (5 pts) Sketch I as a function of time.

I falls from 0.5 A to 0.214 A

