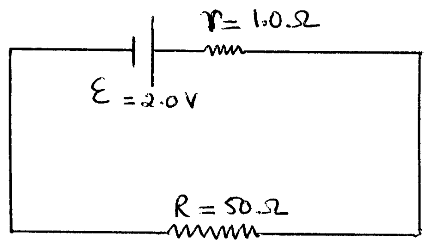
KING FHAD UNIVERSITY OF PETROLEUM & MINERALS
DEPARTMENT OF PHYSICS

PHYSICS 102 (992)
SOLUTIONS (CHAPTER 28)

Q.1 A wire of resistance 5.0 Ω is connected to a battery whose emf E is 2.0 V and whose internal resistance is 1.0 Ω. In 2.0 min, (a) How much energy is transferred from chemical to electrical form? (b) How much energy appears in the wire as thermal energy? (c) Account for the difference between (a) and (b).



$$P = I^2(R+r) \,, \quad I = \frac{\varepsilon}{r+R}$$

$$P = \left(\frac{\varepsilon}{R+r}\right)^2 (R+r) = \frac{\varepsilon^2}{R+r} = \frac{(2)^2}{5+1} = 0.67\ W$$

or $P = \varepsilon i = \dfrac{\varepsilon^2}{(R+r)}$

(a) In two minutes

$(0.67)(2)(60) = \boxed{80\ J}$ of energy is transformed from chemical to electrical.

(b) $P = I^2 R = \left[\dfrac{\varepsilon}{(R+r)}\right]^2 R = \dfrac{2^2}{(5+1)^2}(5) = 0.56\ W$

In two minutes

$(0.56)(2)(60) = \boxed{66.7\ J}$ of energy will appear as heat in the wire.

(c) $80 - 66.7 = 13.3\ J$ will be lost in the internal resistor of the battery.

$$\left(\frac{\mathcal{E}}{r+R}\right)^2 (r)(2)(60) = \left(\frac{2}{1+5}\right)^2 (1)(2)(60) = 13.3\ J$$

Q.2 In Figure 28.2, if the potential at point P is 100*V*, what is the potential at point Q?

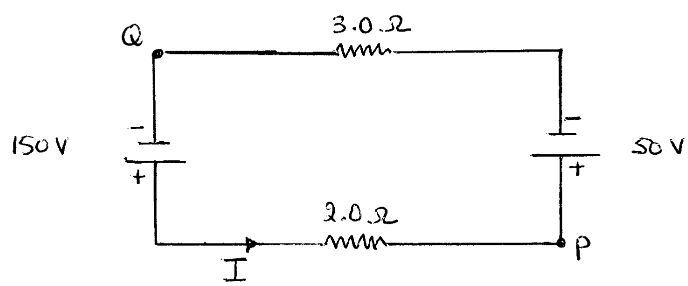


FIGURE 28.2

Apply Kirchhoff's law

$$-150 + 3I + 50 + 2I = 0$$

$$5I = 100 \Rightarrow I = \frac{100}{5} = 20\ A.$$

Now start from P go to Q through 3.0 Ω resistor

$$V_P - 50 - 3I = V_Q$$

$$V_Q = 100 - 50 - 3(20) = 100 - 50 - 60 = \boxed{-10\ \text{Volts}}$$

Or go against the current

$$V_P + 2I - 150 = V_Q$$

$$V_Q = 100 + 2(20) - 150 = \boxed{-10\ \text{Volts}}$$

Q.3 In the Figure 28.3, what is the equivalent resistance of the network shown? (b) What is the current in each resistor? Put $R_1 = 100\ \Omega$, $R_2 = R_3 = 50\ \Omega$, $R_4 = 75\ \Omega$ and $E = 6.0\ V$; assume the battery is ideal.

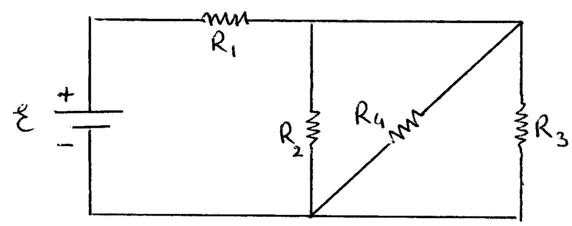


FIGURE 28-3

(a) $$R_{eq} = \frac{1}{\frac{1}{50} + \frac{1}{75} + \frac{1}{50}} + 100 = \boxed{118.8\ \Omega \text{ or } 1.2\times10^2\ \Omega}$$

(b) $$I_1 = \frac{6.0}{1.2\times10^2} = 0.0505\ A = \boxed{51\ mA.}$$

$$V_1 = I_1 R_1 = (0.0505)(100) = 5.05\ \text{Volts}$$

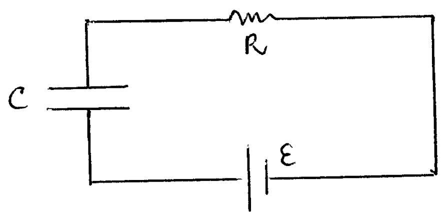
$$V_{2,3,4} = 6 - 5.05 = 0.95\ \text{Volts}$$

$$I_2 = \frac{0.95}{50} = 0.019\ A = \boxed{19\ mA}$$

$$I_3 = \frac{0.95}{50} = 0.019\ A = \boxed{19\ mA}$$

$$I_4 = \frac{0.95}{75} = 0.013\ A = \boxed{13\ mA}$$

Q.4 A 300 $M\Omega$ resistor and a 1.00 μF capacitor are connected in series with an ideal battery of $E = 4.00V$. At 1.00 s after the connection is made, what are the rates at which (a) the charge of the capacitor is increasing, (b) energy is being stored in the capacitor, (c) thermal energy is appearing in the resistor, and (d) energy is being delivered by the battery?



$$\tau = (3.00 \times 10^6)(1 \times 10^{-6}) = 3.0\ s$$

(a) $$Q = \varepsilon C(1 - e^{-t/\tau})$$

$$\frac{dQ}{dt} = \varepsilon C\left(\frac{1}{\tau} e^{-t/\tau}\right) = \frac{(4)(1.0 \times 10^{-6})}{3} e^{-1/3}$$

$$= 9.55 \times 10^{-7}\ C/s = \boxed{0.955\ \mu C/s}$$

(b) $$u = \frac{1}{2} C V^2 = \frac{1}{2} C \left(\frac{Q}{C}\right)^2 = \frac{Q^2}{2C}$$

$$\frac{du}{dt} = \frac{1}{2C} 2Q \cdot \frac{dQ}{dt} = \varepsilon(1 - e^{-t/\tau}) \frac{dQ}{dt}$$

$$= 4(1 - e^{-1/3})(0.955)\ \mu J/s = \boxed{1.08\ \mu J/s}$$

(c) $$P = i^2 R = \left(\frac{\varepsilon}{R} e^{-t/\tau}\right)^2 R = \frac{\varepsilon^2}{R} e^{-2t/\tau}$$

$$P = \frac{4^2}{3 \times 10^6} e^{-2/3} = \boxed{274\ \mu W = 274\ \mu J/s}$$

(d) $$P = i\varepsilon = \varepsilon\left(\frac{\varepsilon}{R} e^{-t/\tau}\right) = \frac{\varepsilon^2}{R} e^{-t/\tau} = \frac{42}{3 \times 10^6} e^{-1/3}$$

$$\boxed{P = 3.82\ \mu W = 3.82\ \mu J/s}$$

Q.5 The potential difference between the plates of a leaky (meaning that charge leaks from one plate to the other) 2.0 μF capacitor drops to one-fourth its initial value in 2.0 s. What is the equivalent resistance between the capacitor plates?

$$C = 2\mu F$$

$$\mathcal{E} = \mathcal{E}_o e^{-t/\tau}$$

$$\frac{\mathcal{E}}{\mathcal{E}_o} = e^{-t/\tau}$$

$$\frac{1}{4} = e^{-2/\tau}$$

$$-\ln 4 = -\frac{2}{\tau}, \quad \tau = RC = \frac{2}{\ln 4} \Rightarrow R = \frac{2}{(2\times 10^{-6})\ln 4}$$

$$\boxed{R = 0.721\ M\Omega.}$$