PHY 1B(b) Chapter 18 Solutions

(5)

a) For parallel resistors,

$$R_{eq,p} = \left(\frac{1}{7.00\,\Omega} + \frac{1}{10.0\,\Omega}\right)^{-1} = 4.12\,\Omega$$

$$\Rightarrow R_{ab} = R_4 + R_{eq,p} + R_9 = 4.00\,\Omega + 4.12\,\Omega + 9.00\,\Omega = \boxed{17.1\,\Omega}$$

b) $$I_{ab} = \frac{(\Delta V)_{ab}}{R_{ab}} = \frac{34.0\,V}{17.1\,\Omega} = 1.99\,A$$

$$\Rightarrow I_4 = I_9 = 1.99\,A$$

Also, $$(\Delta V)_p = I_{ab} R_{eq,p} = (1.99\,A)(4.12\,\Omega) = \boxed{8.18\,V}$$

$$\Rightarrow I_7 = \frac{(\Delta V)_p}{R_7} = \frac{8.18\,V}{7.00\,\Omega} = \boxed{1.17\,A}$$

$$\Rightarrow I_{10} = \frac{(\Delta V)_p}{R_{10}} = \frac{8.18\,V}{10.0\,\Omega} = \boxed{0.818\,A}$$

(8)

a) $R_{p,10,5} = \frac{(10\,\Omega)(5\,\Omega)}{10\,\Omega + 5\,\Omega} = 10/3\ \Omega$

$R_{s,10/3,4} = 10/3\ \Omega + 4\,\Omega = 7.33\ \Omega$

$R_{p,7.33,3} = \frac{(7.33\,\Omega)(3\,\Omega)}{7.33\,\Omega + 3\,\Omega} \approx 2.13\ \Omega$

$R_{eq} = 3\,\Omega + 2.13\,\Omega = 5.13\ \Omega$

b) $P = \frac{(\Delta V)^2}{R_{eq}} \Rightarrow \Delta V = \sqrt{P \cdot R_{eq}}$

$\Rightarrow \Delta V = \sqrt{(4\ W)(5.13\,\Omega)} = \boxed{4.53\ V}$

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(14) Parallel combo of $3\,\Omega$ and $1\,\Omega$ has resistance

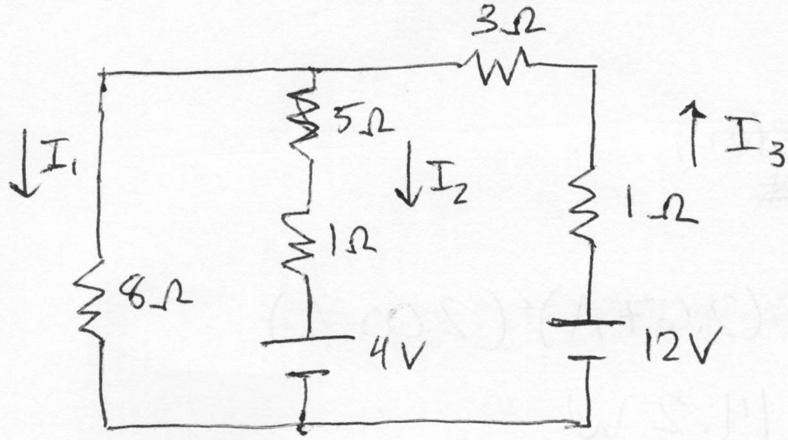
$R_p = \frac{(3\,\Omega)(1\,\Omega)}{3\,\Omega + 1\,\Omega} = .75\ \Omega$

$R_{eq,T} = 2\,\Omega + 0.75\,\Omega + 4\,\Omega = 6.75\ \Omega$

$\Rightarrow$ current supplied by battery is

$I = \frac{\Delta V}{R_{eq}} = \frac{18\ V}{6.75\,\Omega} = 2.67\ A$

(17)



Kirchhoff's loop rule on right most loop.

$$+12.0\,V-(1\Omega+3\Omega)I_3-(5\Omega+1\Omega)I_2-4.0\,V=0$$

$$\Rightarrow (2\Omega)I_3+(3\Omega)I_2=4\,V$$

On leftmost loop,

$$+4\,V+(1\Omega+5\Omega)I_2-(8\Omega)I_1=0$$

$$\Rightarrow (4\Omega)I_1-(3\Omega)I_2=2\,V$$

Also, from Kirchhoff's junction rule,

$$I_3=I_1+I_2$$

Three equations and three unknowns, so we can solve this to give

$\boxed{I_1=0.846\,A}$ $\boxed{I_2=0.462\,A}$ $\boxed{I_3=1.31\,A}$

(14) In $2\,\Omega$ ~~circuit~~ resistor,

$$P_2 = I^2 R^2 = (2.67\text{ A})^2(2.00\,\Omega)$$
$$= 14.2\text{ W}$$

In $4\,\Omega$ resistor,

$$P_4 = I^2 R_4 = (2.67\text{ A})^2(4.00\,\Omega)$$
$$= 28.4\text{ W}$$

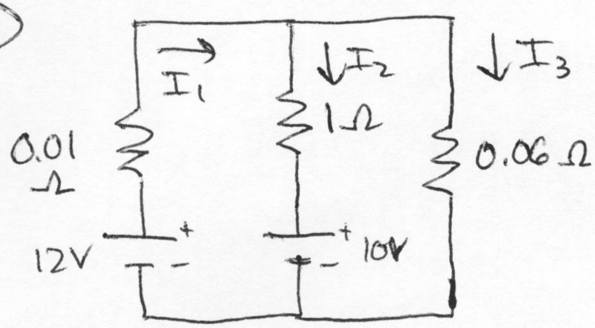
Potential difference across parallel combo of $3 + 1\,\Omega$ resistors,

$$(\Delta V)_p = IR_p = (2.67\text{ A})(0.75\,\Omega) = 2.00\text{ V}$$

$$\Rightarrow P_3 = \frac{(\Delta V)_p^2}{R_3} = \frac{(2.00\text{ V})^2}{3.00\,\Omega} = \boxed{1.33\text{ W}}$$

and $$P_1 = \frac{(\Delta V)_p^2}{R_1} = \frac{(2.00\text{ V})^2}{1.00\,\Omega} = \boxed{4.00\text{ W}}$$

(26)



Outer perimeter:

$$+12\,V - (0.01\,\Omega)I_1 - (0.06\,\Omega)I_3 = 0$$

$$\Rightarrow I_1 + 6I_3 = 1.2 \times 10^3\,A$$

For rightmost loop,

$$+10\,V + (1\,\Omega)I_2 - (0.06\,\Omega)I_3 = 0$$

$$\Rightarrow I_2 - 0.06\,I_3 = -10\,A$$

Kirchhoff's junction rule,

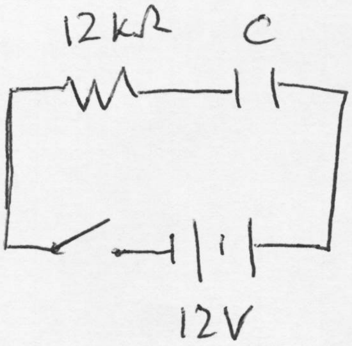
$$I_1 = I_2 + I_3$$

Using these equations,

$$I_2 = 0.28\,A \text{ (in dead battery)}$$

$$I_3 = 1.7 \times 10^2\,A \text{ (in starter)}$$

(34)



Charge on capacitor at time t is

$$Q = Q_{max}\left(1 - e^{-t/\tau}\right)$$

$$Q = C(\Delta V) \text{ and } Q_{max} = C\mathcal{E}$$

$$\Rightarrow \cancel{C}(\Delta V) = \cancel{C}\mathcal{E}\left(1 - e^{-1s/\tau}\right)$$

$$10\,V = 12\,V\left(1 - e^{-1s/\tau}\right)$$

$$\Rightarrow \frac{1}{6} = e^{-1s/\tau} \Rightarrow e^{1s/\tau} = 6$$

$$\Rightarrow \frac{1s}{\tau} = \ln 6 \Rightarrow \tau = \frac{1s}{\ln 6} \approx 0.56s.$$

Since $\tau = RC$,

$$C = \frac{\tau}{R} = \frac{0.56\,s}{12 \times 10^3\,\Omega} = 4.7 \times 10^{-5}\,F = \boxed{47\,\mu F}$$

(48) From $P = \frac{(\Delta V)^2}{R}$

$$\Rightarrow R = \frac{(\Delta V)^2}{P} = \frac{(120\,V)^2}{60\,W} = 240\,\Omega$$

for each bulb, assuming resistance is constant...

$$R_{eq,\,total} = R_1 + \frac{R_2 R_3}{R_2 + R_3} = 240\,\Omega + \frac{(240\,\Omega)(240\,\Omega)}{480\,\Omega}$$

$$= 360\,\Omega.$$

Therefore, total power delivered to the circuit is

$$P = \frac{(\Delta V)^2}{R_{eq}} = \frac{(120\,V)^2}{360\,\Omega} = \boxed{40\,W}$$

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(54) $Q = Q_{max}(1 - e^{-t/\tau})$

and $\tau = RC = (2.0 \times 10^6\,\Omega)(3.0 \times 10^{-6}\,F) = 6.0\,s$

Want $Q = .90\,Q_{max}$, which gives $0.90 = 1 - e^{-t/\tau}$

$$\Rightarrow e^{-t/\tau} = 0.10 \quad \Rightarrow -t/\tau = \ln(0.10)$$

$$\Rightarrow t = -(6.0\,s)(\ln(0.10)) = \boxed{14\,s}$$