Electricity

4. a. Ideal conductors have no resistance and are thus labelled as wires.

b. Assuming $R_{copper} \ll R_{bulb}$, $\frac{V^2}{R} = P$

$I = \frac{P}{V} = 0.83A$ (2sf)

$\Rightarrow R = \frac{V^2}{P}$

$= 14.4\,\Omega$

c. Assumptions:

① : $R_{copper} \ll R_{bulb}$

$\rho_{copper} \sim 10^{-8}\,\Omega m \Rightarrow R_{copper} \sim \frac{10^{-8}}{10^{-6}} = 10^{-2}\,\Omega$

So, this is a justified assumption.

② : (as 12 V is the terminal PD, internal resistance doesn't matter)

d. $V_b = 12V$, $R_b = 0.03\,\Omega$

e. The bulb is now modelled as a wire

f. $I = \frac{V_b}{R_b} = 400A$

If left connected, the high output power will drain the battery quickly.

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g. $v(t) = 5\sin(2000\pi t)$

h. $r = 10\Omega$, $R = 100\Omega$

$I = \frac{V_s}{R+r}$ $\quad V_t = \frac{V_s R}{R+r} = \frac{50}{11}\sin(2000\pi t)$

i. $4.9 = 5 \cdot \frac{R}{R+r}$

$\Rightarrow 4.9R + 4.9r = 5R$

$\Rightarrow 0.1R = 4.9r$

$\Rightarrow r = \frac{R}{5} = \frac{1}{49}R = 2.0\,\Omega$ (2sf)

5. a. $R_{AB} = \frac{1}{\frac{1}{3}+\frac{1}{6}} + \frac{1}{\frac{1}{3}+\frac{1}{6}} = 4\Omega$

b. $V_{eff} = 90V$, $R_{eff} = 30\Omega$

$I = 3A$

c. Unless the sequence fits tests for convergence, $R \to \infty$

$R_1, R_2, R_3, \ldots$

(theorem)

d. Unless $\frac{1}{R_1} + \frac{1}{R_2} \ldots$ converges to a finite value, $R \to 0$

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d. First condition, $I_1 = I_2 = I$, $IR_1 = 5V$, $IR_2 = 10V$

$\Rightarrow R_2 = 2R_1$

second: $I_2 = I_1 - I_3$ $\quad I_3 = 1mA$

$I_1 R_1 = 7V$ $\quad I_1 R_2 - I_3 R_2 = 8V$

$\Rightarrow I_1 R_1 - I_3 R_1 = 4V$

$\Rightarrow I_3 R_1 = 3V \Rightarrow R_1 = \frac{3}{1\times10^{-3}} = 3k\Omega$

$R_2 = 6k\Omega$

6. a. $C_{eq} = \frac{1}{\frac{1}{2.2} + \frac{1}{1.68}} = 0.95\mu F$ (2sf)

b. $V_R = IR$, $V_C = \frac{Q}{C} = \frac{\int i\,dt}{C}$, $V_L = L\frac{di}{dt}$

c. Resistor; $i(t) = \frac{v(t)}{R}$,

Capacitor, $i(t) = +CV_0\omega\cos(\omega t)$

inductor; $i(t) = -\frac{V_0}{\omega L}\cos(\omega t)$

d. $P_R(t) = \frac{V_0^2 \sin^2(\omega t)}{R}$ $\quad P_C = C\omega V_0^2 \sin\omega t \cos\omega t$

$P_L = \frac{V_0^2}{\omega L}\sin\omega t \cos\omega t$

e. $\langle P_R \rangle = \frac{V_0^2}{2R}$, $\langle P_L \rangle = \langle P_C \rangle = 0$

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