HOMEWOKR 6

18-6C a ii - less then any of the resistors in the group because there are more paths available to the current

$$R_{tot} = \frac{1}{\frac{1}{3} + \frac{1}{5}} = \frac{15}{8} \simeq 2\,\Omega$$

b i - greater then any of the resistors in the group because the current is opposed by each resistor in turn

$$R_{tot} = 3 + 5 = 8\,\Omega$$

18-12C set A is wired in parallel because removing one bulb does not create an open circuit for the other bulbs while set B is wired in series and removing one bulb creates an open circuit for the rest

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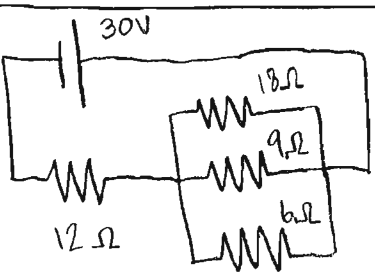
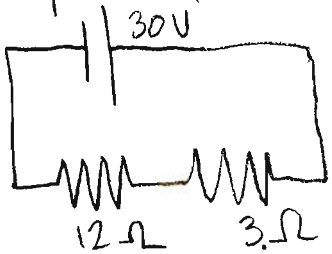
18-6



begin by combining the three resistors in parallel

$$R_1 = \left(\frac{1}{18} + \frac{1}{9} + \frac{1}{6}\right)^{-1} = 3.0\,\Omega$$

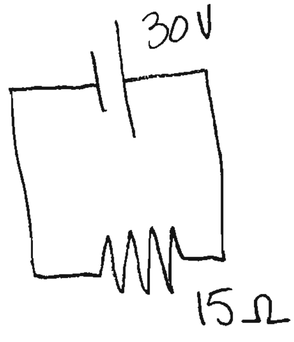
now replace the three resistors with an equivalent resistor



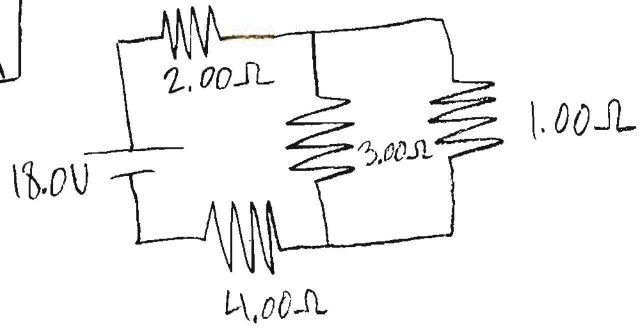
now combine the two resistors in series

$$R_2 = 12 + 3. = 15\,\Omega$$

hence the equivalent circuit is



18-14



$P = I\Delta V = I^2 R$

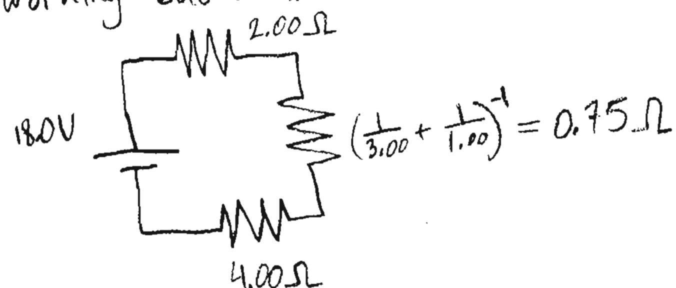
one way to solve this is to calculate the equivalent resistance and then work backwards

$$R_{tot} = 4.00 + 2.00 + \left(\frac{1}{3.00} + \frac{1}{1.00}\right)^{-1} = 6.75\,\Omega$$

by Ohm's law

$$I = \frac{\Delta V}{R} = \frac{18.0}{6.75} = 2.67\,A$$

working backwards



hence the power delivered is

$$P_{4\Omega} = (2.67)^2(4) = 28.5\,W$$

$$P_{2\Omega} = (2.67)^2(2) = 14.3\,W$$

the voltage drop across the parallel combination of 3.00Ω and 1.00 Ω is

$$\Delta V = IR = (2.67)(0.75) = 2.00\,V$$

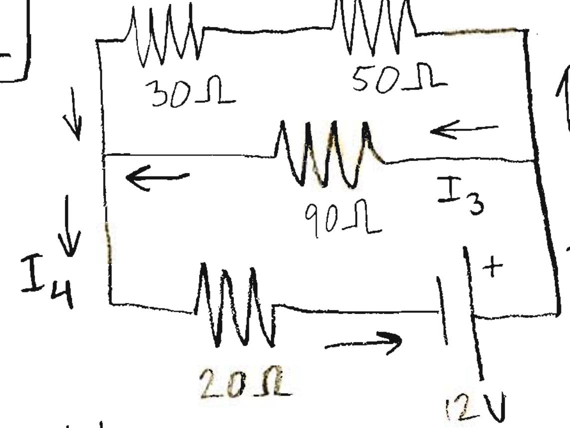
$$P = I\Delta V = \frac{(\Delta V)^2}{R}$$

since the 3.00Ω and 1.00Ω resistors are in parallel, the voltage drop is the same across both and the power delivered is

$$P_{3\Omega} = \frac{(2.00)^2}{3.00} = 1.33\,W$$

$$P_{1\Omega} = \frac{(2.00)^2}{1.00} = 4.00\,W$$

18-22



$P = I\Delta V$

another way to solve this is to use Kirchoff's rules to find the current across the 50Ω resistor

first draw arbitrary arrows indicating the direction of current and then use the two rules in combination with Ohm's law

$12 - I_3(90) - I_4(20) = 0$ loop rule ①

$12 - I_2(50) - I_2(30) - I_4(20) = 0$ loop rule ②

$I_1 = I_2 + I_3$ junction rule ③

$I_2 + I_3 = I_4$ junction rule ④

since there are four devices, there must be four unknowns and hence four independent equations

now solve for I_2

$I_1 = I_2 + I_3 = I_4 \Rightarrow I_1 = I_4$ combining ③ and ④

$I_3 = I_4 - I_2$ using ④, substitute into ①

$12 - 90(I_4 - I_2) - 20I_4 = 0 \Rightarrow 12 + 90I_2 - 110I_4 = 0$ ⑤

$12 - 80I_2 - 20I_4 = 0 \Rightarrow I_4 = \dfrac{12 - 80I_2}{20}$

plug into ⑤

$12 + 90I_2 - 110\left(\dfrac{12 - 80I_2}{20}\right) = 0 \Rightarrow I_2 = 0.10\text{ A}$

and power delivered $P = I_2^2 R = (0.1)^2(50) = 0.5\text{ W}$

$\boxed{18-30}$ $\tau = RC$

using Ohm's law $\Delta V = IR \Rightarrow [R] = \frac{[V]}{[I]}$

and definition of capacitance $Q = CV \Rightarrow [C] = \frac{[Q]}{[V]}$

and definition of current $I = \frac{\Delta Q}{\Delta t} \Rightarrow [I] = \frac{[Q]}{[T]} \Rightarrow [Q] = [I][T]$

finally $[\tau] = [R][C] = \frac{\cancel{[V]}}{[I]}\frac{[Q]}{\cancel{[V]}} = \frac{\cancel{[I]}[T]}{\cancel{[I]}} = [T]$

hence τ has units of time

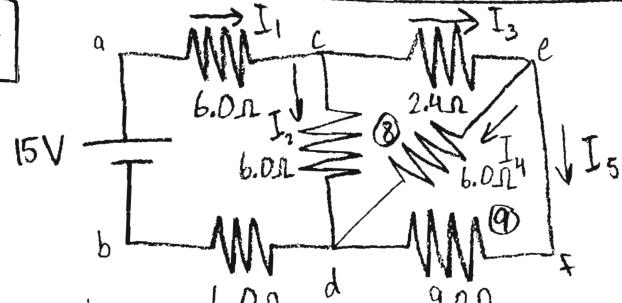
$\boxed{18-40}$ the total power needed by both devices is $1200 + 1200 = 2400\,W$

the maximum power available from this line is

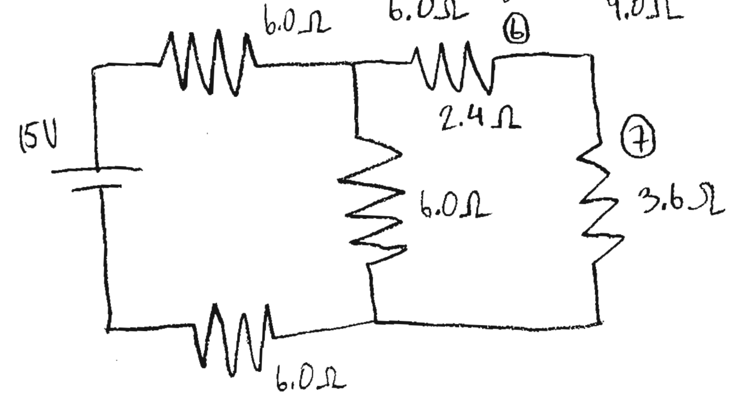
$$P_{MAX} = (\Delta V) I_{MAX} = (120)(15) = 1800\,W$$

$1800 < 2400$ hence both devices cannot operate together

$\boxed{18-47}$

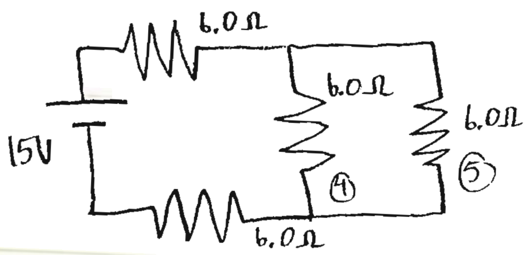


since the question asks for it, solve this by finding the equivalent resistance and working backwards



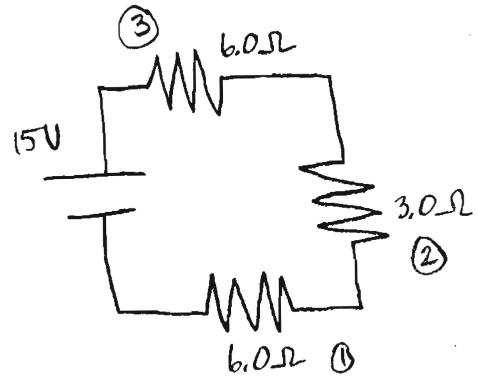
a 9.0Ω and 6.0Ω in parallel give

$$R_1 = \left(\frac{1}{9.0} + \frac{1}{6.0}\right)^{-1} = 3.6\,\Omega$$



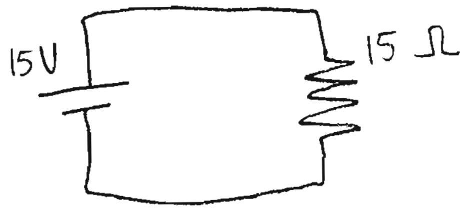
a 2.4Ω and 3.6Ω in series give

$$R_2 = 2.4 + 3.6 = 6.0\,\Omega$$



two 6.0Ω in parallel give

$R_3 = \left(\frac{1}{6.0} + \frac{1}{6.0}\right)^{-1} = 3.0\,\Omega$



three resistors in series give

$R_4 = (6.0\,\Omega + 3.0\,\Omega + 6.0\,\Omega) = 15\,\Omega$

hence the effective resistance is 15 Ω

working backwards, the current across resistors 1, 2, 3 is

$I = \frac{\Delta V}{R} = \frac{15}{15} = 1.0\text{ A}$

and the voltage drop across 1 and 3 is $\Delta V = IR = (1)(6.0) = 6.0\text{ V}$

giving power dissipation of $P_1 = P_3 = IV = (1)(6) = 6.0\text{ W}$

resistor 3 is actually 4 and 5 in parallel so they both have a voltage drop of 3.0 V, a current of $I = \frac{\Delta V}{R} = \frac{3}{6} = 0.5\text{ A}$

and $P_4 = IV = (0.5)(3) = 1.5\text{ W}$

resistor 5 is actually 6 and 7 in series so they both have a current of 0.5 A

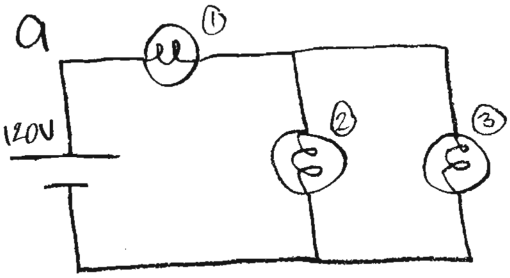
the voltage drop across 7 is $\Delta V = IR = (0.5)(3.6) = 1.8\text{ V}$ while the drop across 6 is $\Delta V = (0.5)(2.4) = 1.2\text{ V}$ and power dissipation of $P_6 = I\Delta V = (0.5)(1.2) = 0.6\text{ W}$

finally resistor 7 is actually 8 and 9 in parallel so they both have a voltage drop of 1.2 V

the current across 8 is $I = \frac{1.8}{6.0} = 0.3\text{ A}$ and power dissipation of $P_8 = (0.3)(1.8) = 0.54$

the current across 9 is $I = \frac{1.8}{9.0} = 0.2\text{ A}$ and power dissipation of $P_9 = (0.2)(1.8) = 0.36\text{ W}$

18-48 a



each bulb is rated 60.0 W at 120 V

using $P = \frac{(\Delta V)^2}{R} \Rightarrow R = \frac{(\Delta V)^2}{P}$

the resistance of each bulb is

$$R = \frac{(120)^2}{60} = 240\,\Omega$$

the equivalent resistance of this circuit is

$$R_{tot} = 240 + \left(\frac{1}{240} + \frac{1}{240}\right)^{-1} = 360\,\Omega$$

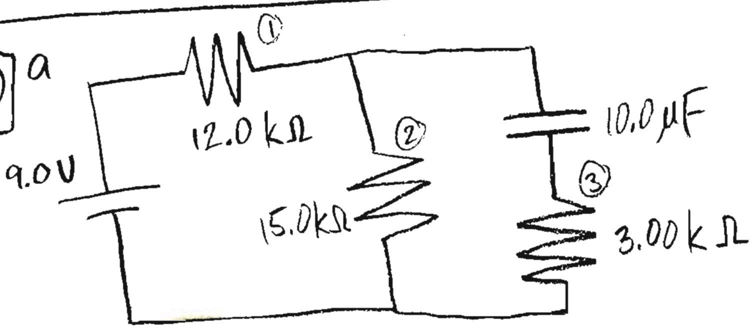
hence the total power delivered is $P = \frac{(\Delta V)^2}{R} = \frac{(120)^2}{360} = 40.0\,W$

b the total current is $I = \frac{\Delta V}{R} = \frac{120}{360} = \frac{1}{3}\,A$

hence the voltage drop across bulb 1 is $\Delta V = IR = \left(\frac{1}{3}\right)(240) = 80.0\,V$

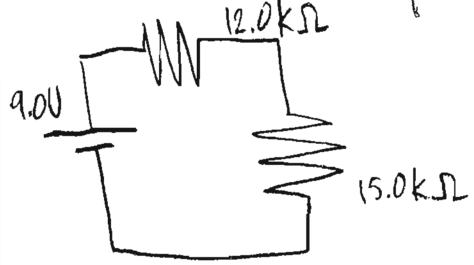
using the loop rule, the voltage drop across both bulbs 2 and 3 is $120 - 80 = 40.0\,V$

18-50 a



when a capacitor becomes fully charged, there is no current across it and hence no current across resistor 3 and by $\Delta V = IR = (0)(3000) = 0$ no voltage drop also

the circuit can be simplified as



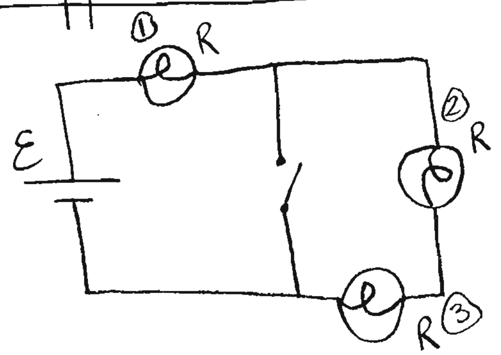
the two resistors are in series so the equivalent resistance is just $12.0k + 15.0k = 27.0\,k\Omega$

$$I = \frac{\Delta V}{R} = \frac{9}{27{,}000} = 3.3 \times 10^{-4}\,A = 333\,\mu A$$

b to find the charge on the capacitor use $Q = C\Delta V$
the voltage drop across the capacitor is the same as across resistor ② and is $\Delta V = IR = (3.3\times10^{-4})(15\times10^{3}) = 4.95\,V$

$$Q = (10.0\times10^{-6})(4.95) = 4.95\times10^{-5} = 49.5\,\mu C$$

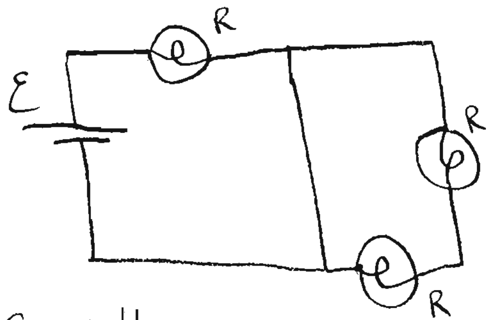
What happens to the bulbs?



a if the switch is open, the circuit consists of three identical bulbs in series and hence all three have the same brightness

b the equivalent resistance is $R_{eq} = R+R+R = 3R$
and the current through the battery is $I = \frac{\Delta V}{R_{eq}} = \frac{\varepsilon}{3R}$

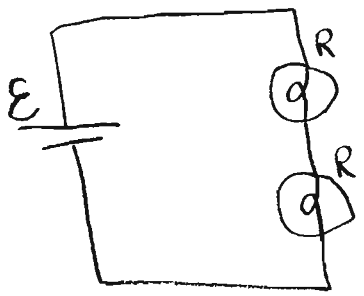
c if the switch is closed, the circuit becomes



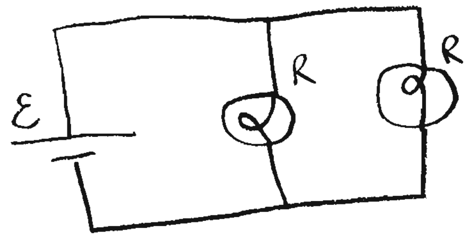
since wires are considered to have no resistance, no current flows through the branch containing bulbs ② and ③ and they are both off, hence dimmer then before

as for bulb ①, it is now brighter then before because the brightness of a bulb increases with current and because the equivalent resistance of the circuit is now just R, the current through it is 3 times greater

A battery and two bulbs



①



②

a both bulbs have the same brightness because the current is the same through both due to the symmetry of the circuit

b $R_{eq} = R + R = 2R$

$$I = \frac{\Delta V}{R_{eq}} = \frac{\varepsilon}{2R}$$

$$\Delta V = IR = \frac{\varepsilon}{2\cancel{R}}\cancel{R} = \frac{\varepsilon}{2}$$

$$P = I\Delta V = \frac{\varepsilon}{2R}\frac{\varepsilon}{2} = \frac{\varepsilon^2}{4R}$$

c both bulbs have the same brightness because the current is the same through both due to the symmetry of the circuit

d $R_{eq} = \left(\frac{1}{R} + \frac{1}{R}\right)^{-1} = \frac{R}{2}$

$$I = \frac{\Delta V}{R_{eq}} = \frac{\varepsilon}{R}$$

$\Delta V = \varepsilon$ because in parallel

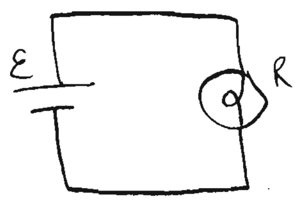
$$P = I\Delta V = \frac{\varepsilon}{R}\varepsilon = \frac{\varepsilon^2}{R}$$

e bulbs in system ② are brighter because $I_2 > I_1$

f if a bulb in system ① burns out, the other will go out as well because it will now be an open circuit

if a bulb in system ② burns out, the other will not go out because its part of the circuit will still be closed

when one bulb in system ② burns out, the circuit becomes



with a new current $I_2^{AFTER} = \frac{\Delta V}{R_{eq}} = \frac{\varepsilon}{R}$

since $I_2^{BEFORE} = I_2^{AFTER}$, the bulb will be the same brightness

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Tutorial Problem

① $C > A > B$

C has the most resistance because it is two bulbs in series, A is next because it is just one bulb, and B has lowest resistance because it is two in parallel and hence there are more paths for the current

② assuming all bulbs to be the same and have a resistance of R

$R_A = R$ $\qquad R_B = \left(\frac{1}{R} + \frac{1}{2R}\right)^{-1} = \frac{2}{3}R$

$R_C = R + R = 2R$ $\qquad R_D = \left(\frac{1}{R} + \frac{1}{R}\right)^{-1} = \frac{R}{2}$

hence $C > A > B > D$