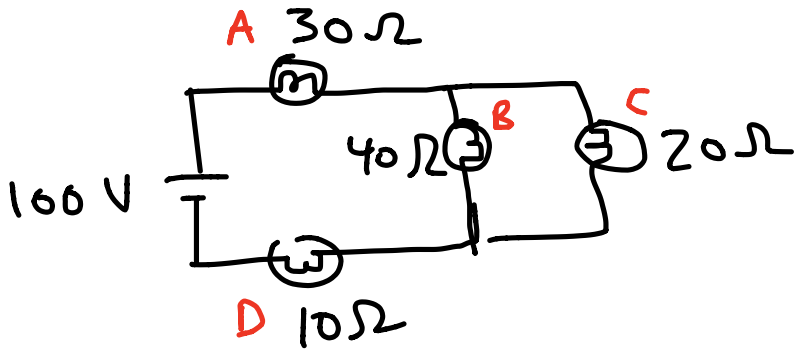
Four bulbs are connected in the circuit below to a 100 V power source.



a) Determine the power dissipated by each bulb.
b) Another bulb is connected parallel to bulbs B and C. How does the brightness of each bulb change?

Bulbs A and D become

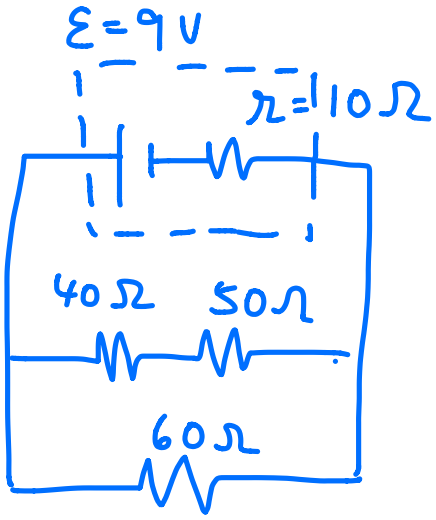
___ brighter ___ dimmer ___ remain the same

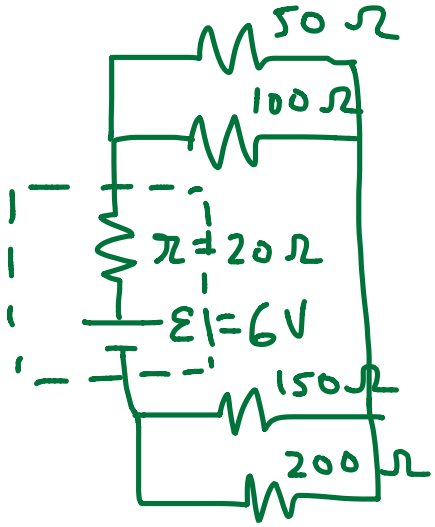
Bulbs B and C become

___ brighter ___ dimmer ___ remain the same

Explain.

Determine the terminal voltage of the battery for each circuit.





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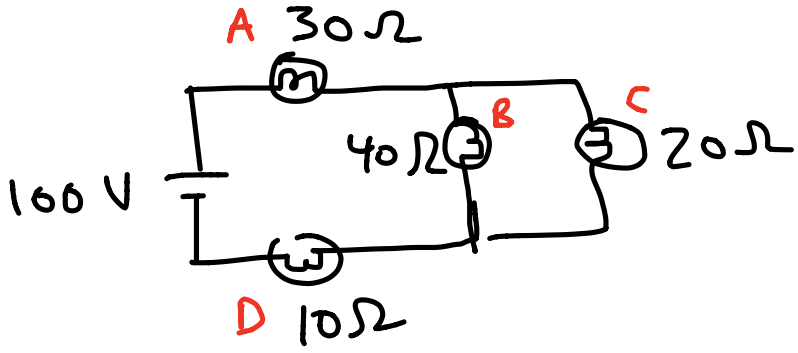


a) Determine the power dissipated by each bulb.
b) Another bulb is connected parallel to bulbs B and C. How does the brightness of each bulb change?

Bulbs A and D become
_✓_ brighter ___ dimmer ___ remain the same
Bulbs B and C become
___ brighter _✓_ dimmer ___ remain the same
Explain.

a) $\frac{1}{R_{eq}} = \frac{1}{R_B} + \frac{1}{R_C}$

$R_{eq} = \left(\frac{1}{20} + \frac{1}{40}\right)^{-1} = 13.\overline{3}\ \Omega$

$R_T = R_A + R_{eq} + R_D$

$= 30 + 13.\overline{3} + 10 = 53.\overline{3}\ \Omega$

$I_T = \frac{V_T}{R_T} = \frac{100}{53.\overline{3}} = 1.875\ A$

$I_T = I_A = I_{eq} = I_D = 1.875\ A$

$$V_{eq} = I_{eq} R_{eq}$$

$$= (1.875)(13.\overline{3}) = 25\ V$$

$$V_{eq} = V_B = V_C$$

$$P_A = I_A^2 R_A = (1.875)^2(30) = \boxed{105\ W}$$

$$P_B = \frac{V_B^2}{R_B} = \frac{25^2}{40} = \boxed{15.6\ W}$$

$$P_C = \frac{V_C^2}{R_C} = \frac{25^2}{20} = \boxed{31.3\ W}$$

$$P_D = I_D^2 R_D = (1.875)^2(10) = \boxed{35.2\ W}$$

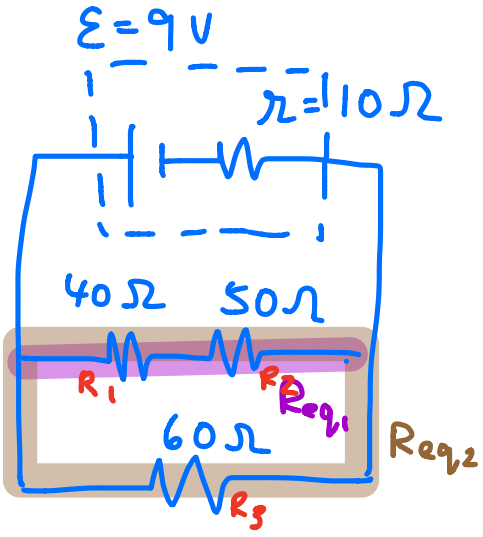
b) WHEN ANOTHER RESISTOR IS ADDED IN PARALLEL TO BULBS B AND C, THE TOTAL RESISTANCE OF THE CIRCUIT DECREASES. BY OHM'S LAW, THE DECREASE IN RESISTANCE RESULTS IN AN INCREASE IN TOTAL CURRENT. AS THIS TOTAL CURRENT PASSES THROUGH BULBS A AND D, THE POWER AND THEREFORE THE BRIGHTNESS INCREASE ($P = I^2R$, $P \propto I^2$).

AS MORE CURRENT PASSES THROUGH BULBS A AND D, BY OHM'S LAW, THE POTENTIAL VOLTAGE ACROSS THE BULBS INCREASES.

SINCE V_T HAS NOT CHANGED, BY KIRCHHOFF'S LOOP RULE, V_B AND V_C MUST DECREASE. THE POWER AND THEREFORE THE BRIGHTNESS DECREASE ($P = \frac{V^2}{R}$, $P \propto V^2$).

ALTERNATE EXPLANATION FOR BULBS B AND C: AS A BULB IS ADDED IN PARALLEL TO BULBS B AND C, THERE IS A NEW PATH FOR CURRENT TO FLOW. THIS REDUCES THE CURRENT TO B AND C. THE POWER AND THEREFORE THE BRIGHTNESS DECREASE ($P = I^2R$, $P \propto I^2$).

Determine the terminal voltage of the battery for each circuit.



$R_{eq1} = R_1 + R_2$

$= 40 + 50 = 90\ \Omega$

$\frac{1}{R_{eq2}} = \frac{1}{R_{eq1}} + \frac{1}{R_3}$

$R_{eq2} = \left(\frac{1}{90} + \frac{1}{60}\right)^{-1}$

$= 36\ \Omega$

$R_T = R_{eq2} + r$

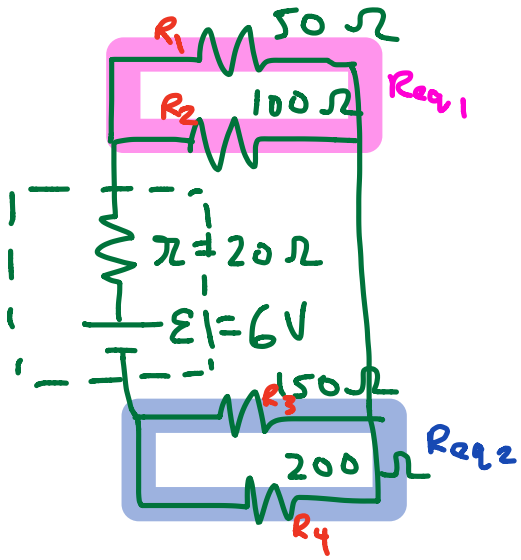
$= 36 + 10 = 46\ \Omega$

$I_T = \frac{V_T}{R_T} = \frac{9}{46} = 0.196\ A$

$V_r = I_r r$

$= (0.196)(10) = 1.96\ V$

$V_{TERMINAL} = \mathcal{E} - V_r = 9 - 1.96 = \boxed{7.04\ V}$



$\frac{1}{R_{eq1}} = \frac{1}{R_1} + \frac{1}{R_2}$

$R_{eq1} = \left(\frac{1}{50} + \frac{1}{100}\right)^{-1} = 33.\overline{3}\ \Omega$

$\frac{1}{R_{eq2}} = \frac{1}{R_3} + \frac{1}{R_4}$

$= \left(\frac{1}{150} + \frac{1}{200}\right)^{-1} = 85.7\ \Omega$

$R_T = R_{eq1} + R_{eq2} + r$

$= 33.\overline{3} + 85.7 + 20 = 139\ \Omega$

$I_T = \frac{V_T}{R_T} = \frac{6}{139} = 0.0432\ A$

$V_r = I_r r$

$= (0.0432)(20) = 0.863\ V$

$V_{TERMINAL} = \mathcal{E} - V_r$

$= 6 - 0.863 = \boxed{5.14\ V}$