



AP[®] Physics B

2002 Sample Student Responses

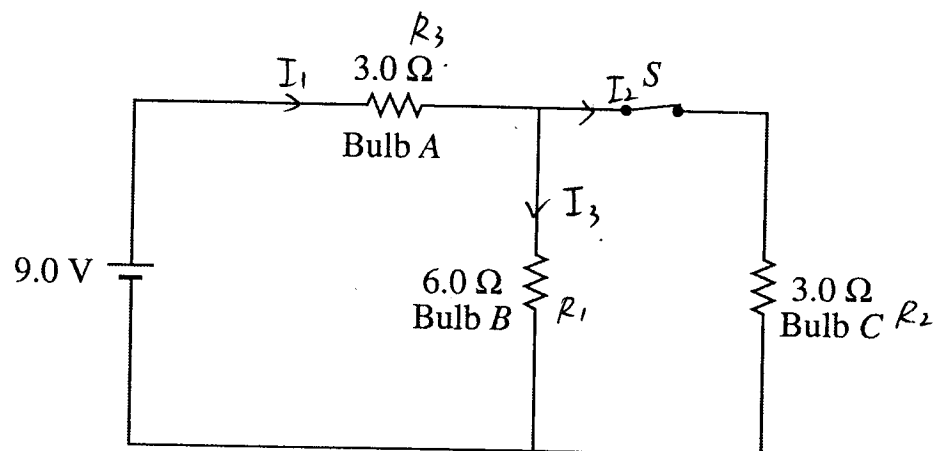
Form B

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3. (15 points)

Lightbulbs of fixed resistance $3.0\ \Omega$ and $6.0\ \Omega$, a $9.0\ \text{V}$ battery, and a switch S are connected as shown in the schematic diagram above. The switch S is closed.

(a) Calculate the current in bulb A.

$$\frac{1}{R_{(6\Omega, 3\Omega)}} = \frac{1}{R_1} + \frac{1}{R_2}$$

$$R = \frac{1}{\left(\frac{1}{R_1} + \frac{1}{R_2}\right)} = \frac{1}{\left(\frac{1}{6} + \frac{1}{3}\right)} = \frac{1}{\left(\frac{1}{6} + \frac{2}{6}\right)} = \frac{6}{3} = 2\ \Omega$$

$$R_{\text{total}} = R_3 + R_{(6\Omega, 3\Omega)}$$

$$= 3 + 2 = 5\ \Omega$$

$$I_{\text{total}} = \frac{V}{R_{\text{total}}}$$

$$= \frac{9}{5} = 1.8\ \text{A} = I_1$$

(b) Which lightbulb is brightest? Justify your answer.

$$P = IV \quad V = IR$$

$$\text{for bulb A } P_A = I_1^2 R_3$$

$$P = I^2 R$$

$$= (1.8)^2 \cdot 3 = 9.7\ \text{W}$$

for bulb B.

$$V_B = V - V_A$$

$$= V - I_1 R_3 = 9 - 1.8 \cdot 3 = 3.6\ \text{V} \quad I_3 = \frac{V_B}{R_1} = \frac{3.6}{6} = 0.6\ \text{A}$$

$$P_B = V_B I_B = 3.6\ \text{V} \cdot 0.6\ \text{A} = 2.2\ \text{W}$$

for bulb C

$$V_C = V_B = 3.6\ \text{V} \quad I_2 = I_1 - I_3 = 1.8 - 0.6 = 1.2\ \text{A}$$

$$P_C = V_C I_C = 3.6\ \text{V} \cdot 1.2\ \text{A}$$

$$= 4.3\ \text{W}$$

$\therefore P_A > P_C > P_B$ \therefore bulb A is the brightest.

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(c) Switch S is then opened. By checking the appropriate spaces below, indicate whether the brightness of each lightbulb increases, decreases, or remains the same. Explain your reasoning for each lightbulb.

i. Bulb A: The brightness ☐ increases ☒ decreases ☐ remains the same

Explanation:

$$R_{\text{(total)}} = R_3 + R_1 = 3 + 6 = 9 \Omega$$

$$I_{\text{(total)}} = \frac{V}{R} = \frac{9V}{9\Omega} = 1A = I_1$$

$$P'_A = I_1^2 R_3 \\ = 1 \cdot 3 = 3W < 9.7W.$$

ii. Bulb B: The brightness ☒ increases ☐ decreases ☐ remains the same

Explanation:

$$I_3 = I_1 = 1A$$

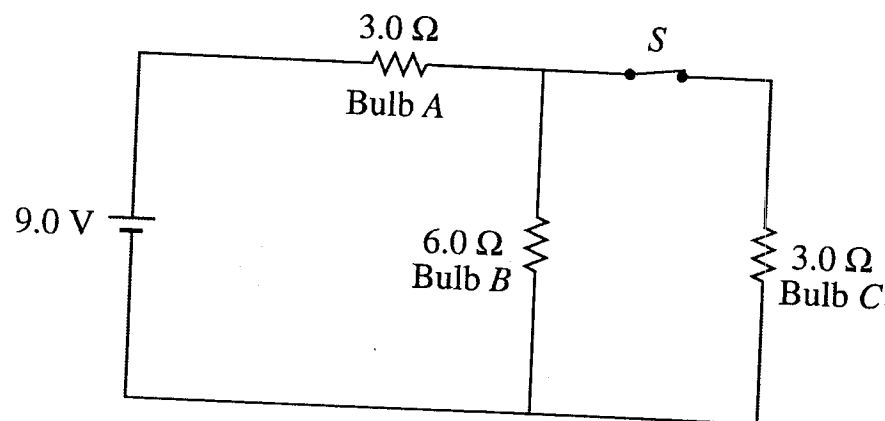
$$P'_B = I_1^2 R_1 \\ = 1 \cdot 6 = 6W > 2.2W$$

iii. Bulb C: The brightness ☐ increases ☒ decreases ☐ remains the same

Explanation:

~~the~~
Bulb C is not connected to the circuit anymore.

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3. (15 points).

Lightbulbs of fixed resistance $3.0\ \Omega$ and $6.0\ \Omega$, a $9.0\ \text{V}$ battery, and a switch S are connected as shown in the schematic diagram above. The switch S is closed.

(a) Calculate the current in bulb A.

$$I = \frac{V}{R}$$

$$R_T = 3 + R_C$$

$$\frac{1}{R_C} = \frac{1}{6} + \frac{1}{3} = \frac{1}{2}$$

$$R_T = 5$$

$$R_C = 2$$

$$I = \frac{9}{5}\ \text{A}$$

all current in circuit must pass through bulb A

$$\therefore I = \frac{9}{5}\ \text{A}$$

(b) Which lightbulb is brightest? Justify your answer.

Bulb A is brightest because the most current passes through it and it uses the most power.

$$P_A = \frac{9}{5} \cdot 3 = \frac{27}{5}\ \text{W}$$

$$P_B = \frac{9}{5} \cdot 6 = \frac{18}{5}\ \text{W}$$

$$V_C = 2\ \text{V}$$

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(c) Switch S is then opened. By checking the appropriate spaces below, indicate whether the brightness of each lightbulb increases, decreases, or remains the same. Explain your reasoning for each lightbulb.

i. Bulb A: The brightness ☐ increases ☒ decreases ☐ remains the same

Explanation: because alternate path of bulb C is removed thereby increasing total resistance and decreasing the current passing through bulb A.

ii. Bulb B: The brightness ☒ increases ☐ decreases ☐ remains the same

Explanation:

$$I = \frac{V}{R} = \frac{9}{9} = 1 \text{ A}$$

previous $I = \frac{9}{15} \text{ A}$

all current in circuit now must pass through bulb B
B is more current passes through bulb B

iii. Bulb C: The brightness ☐ increases ☒ decreases ☐ remains the same

Explanation:

current no longer passes through bulb C

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