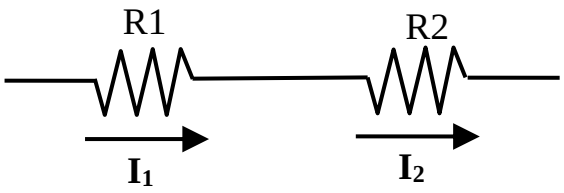
Circuits Concept Tests.

CRKT-1.

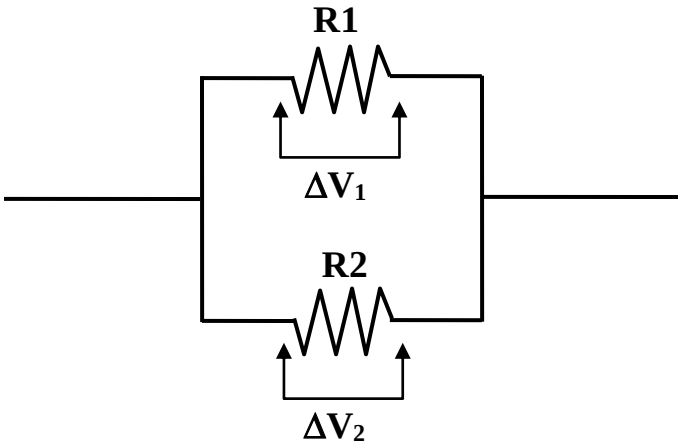
Vote TRUE(A) if both statements below are <u>always</u> true. Otherwise, vote FALSE(B).

BOTH TRUE (A) or ONE OR BOTH FALSE (B) ?

- For resistors in series, the current through each resistor is the **same**, always.



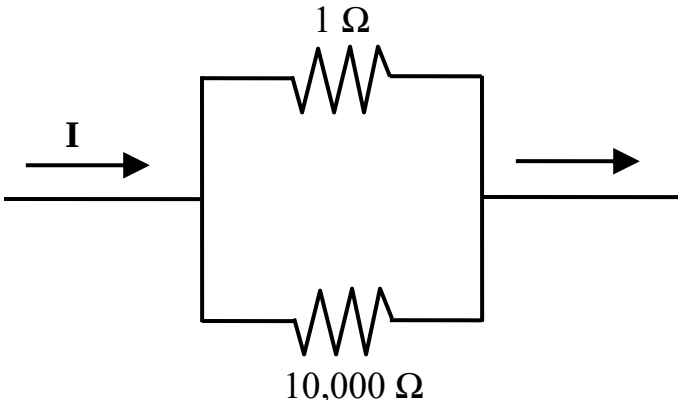
- For resistors in parallel, the voltage across each resistor is the **same**, always.



Answer: Both statements are True!

CRKT-2.

A 1Ω resistor is placed in parallel with a 10,000 Ω resistor as shown.



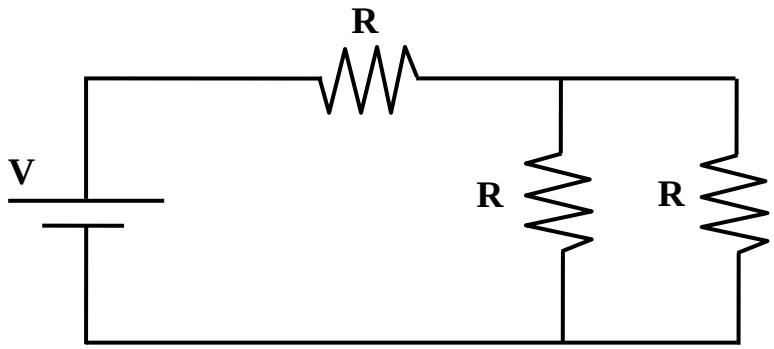
The total, equivalent resistance of these two resistors in parallel is closest to...

A) a little less than 1Ω
B) a little more than 1Ω.
C) 5000 Ω
D) a little less than 10000Ω
E) a little more than 10000Ω

Answer: a little less than 1Ω. You could use the formula $R_{tot} = \frac{1}{\frac{1}{R_1} + \frac{1}{R_2}}$,

$R = \frac{1}{\frac{1}{10000} + \frac{1}{1}} = 0.9990\Omega$. Or, just think: 1Ω is a very low resistance compared to 10000Ω, so almost all the current will flow through the 1Ω resistor, the circuit will behave almost as if the 10000Ω resistor is not present, and the equivalent resistance is close to 1Ω. The question is: is the equivalent resistance a little less or a little greater than 1Ω. Adding the 10000Ω resistor in parallel provides another current path of the flow of charge. More flow means lower resistance.

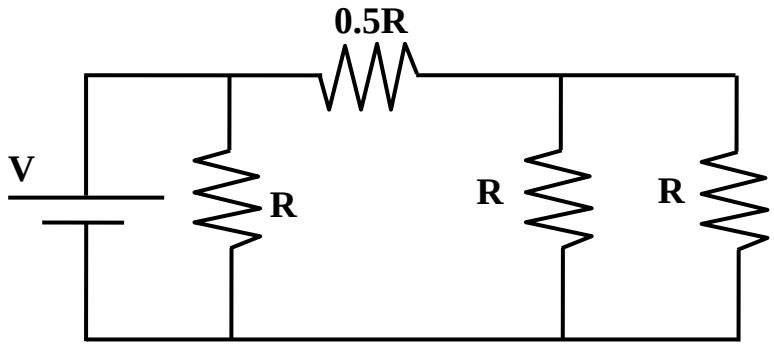
CRKT-3.
Three resistors, each with the same resistance R, are connected as shown. What is the total equivalent resistance which the battery sees?



A) R B) 3R C) 2.5R D) 1.5R E) 0.75R

Answer: 1.5R

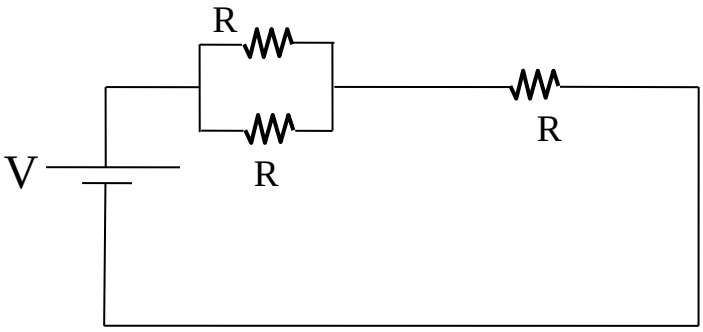
CRKT-4.
Four resistors (R, 0.5R, R, and R) are connected as shown. What is the total equivalent resistance which the battery sees?



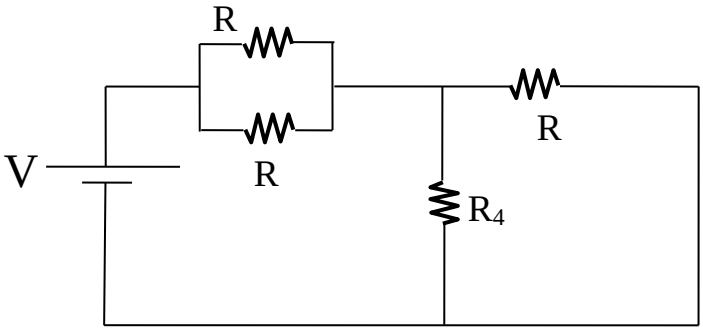
A) 0.5R B) 3.5R C) 2.5R D) 1.5R E) 0.75R

Answer: 0.5R

CRKT-5. A battery is hooked to 3 identical resistors, as shown.



A fourth resistor is added, as shown.

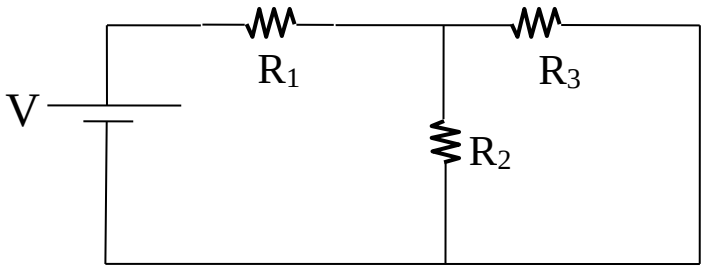


Did the current through the battery increase, decrease, or remain constant when R4 was added to the circuit?

A) increase B) decrease C) remain constant

Answer: the battery current increases. R4 is in parallel with the resistor on the far right. Adding a resistor in parallel *always* reduces the total resistance. Just like adding a new lanes to a highway always improves the traffic flow. With less total resistance, the battery produces more current.

CRKT-6. A battery is hooked to 3 identical resistors, as shown.
Resistors R1 and R2 are
A) in series
B) in parallel
C) neither in series, nor in parallel.

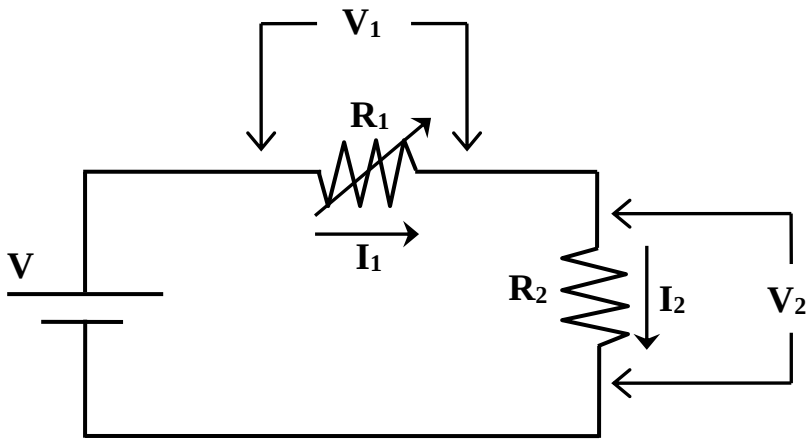


Answer: Neither!

CRKT-7. The circuit below consists of a battery attached to two resistors in series. Resistor R_1 is ***variable***.

When R_1 is **decreased**, the voltage V_2 across R_2 ...

A) increases B) decreases C) stays the same.

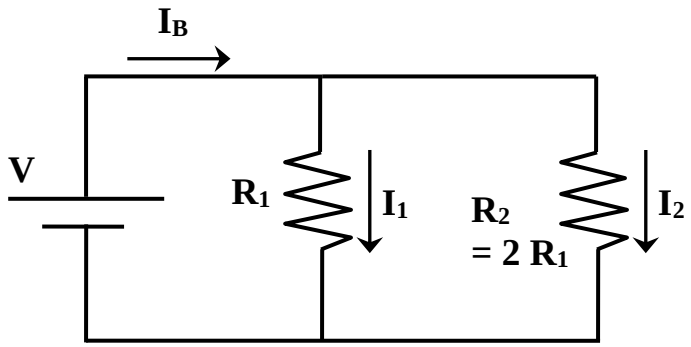


When R_1 is **decreased**, the voltage V_1 across R_1 ...

A) increases B) decreases C) stays the same.

Answer: V2 increases. This is easiest to see if you let R_1 go all the way to zero! Kirchhoff's 2nd Law says that the battery voltage $V=V_1+V_2$. The voltage drop is split between resistors 1 and 2. So V_2 is smaller than the battery voltage V. But if $R_1=0$, then the full battery voltage V is across R_2. V_2 increased as R_1 goes down.

CRKT-8.Two resistors R_1 and R_2 are hooked to a battery in parallel. R_2 is twice as large as R_1. How does the current I_B from the battery compare to the current I_1 though R_1? (Hint: $I_B = I_1 + I_2$.)

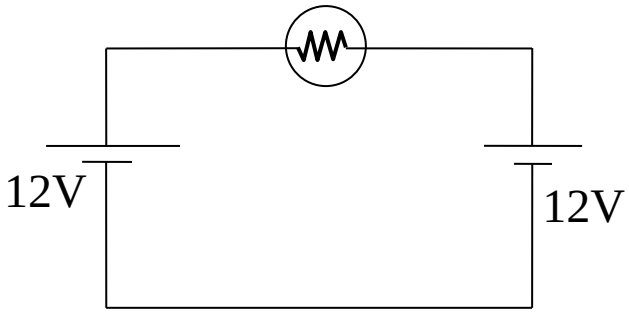


A) $I_B = I_1$ B) $I_B=2I_1$ C) $I_B=3I_1$

D) $I_B=4I_1$ E) $I_B=1.5I_1$

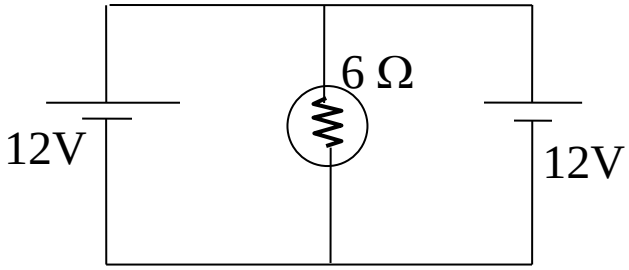
Answer: $I_B=1.5I_1$ Note that $I_2 = 0.5I_1$.

CRKT-9.
Is the light bulb lit?
A) Yes, it is bright. B) No, it is dark.



Answer: the bulb is dark. The batteries are fighting each other. The voltage difference across the light bulb is $\Delta V = 0$. The current is zero, since $\Delta V = I\ R$.

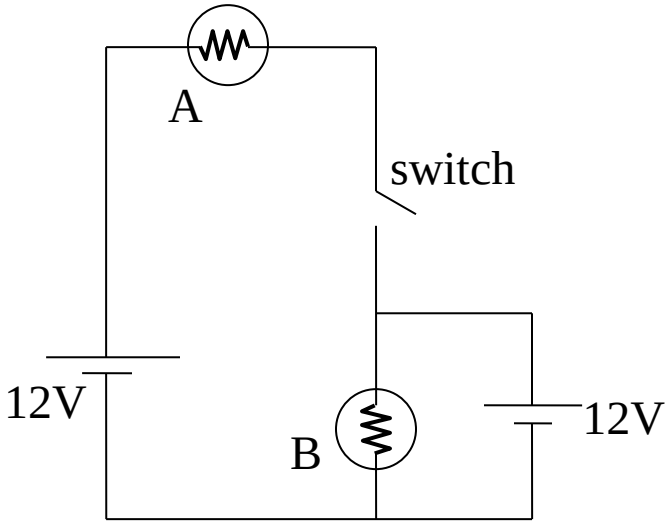
CRKT-10.
What is the current through the bulb?
A) zero B) 2 A C) 4 A D) 1 A



What is the current through the left battery?
A) zero B) 2 A C) 4 A D) 1 A

Answers: The current through the bulb is 2A. The current through each battery is 1A.

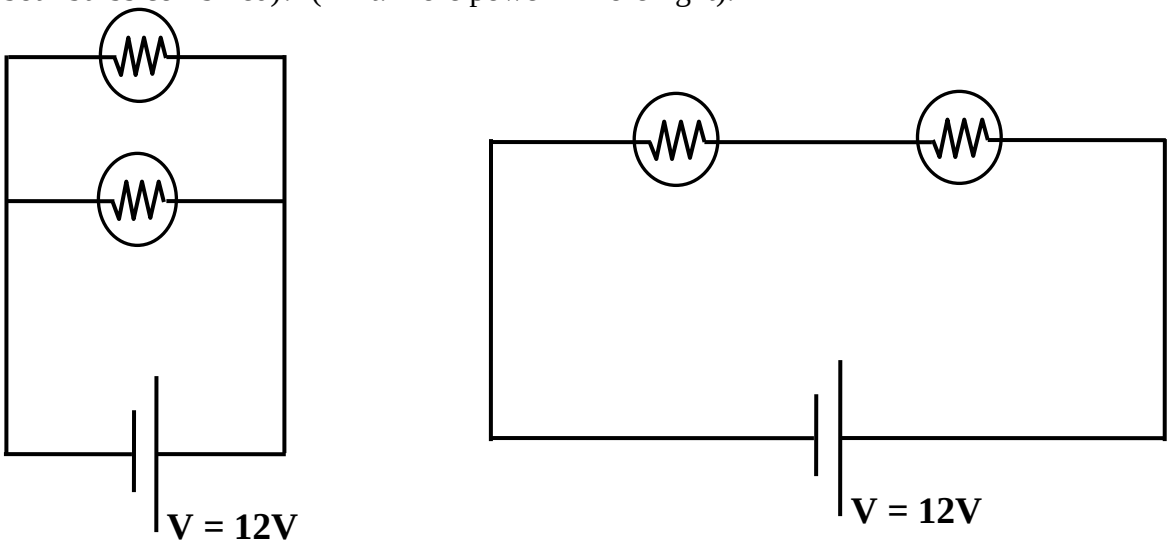
CRKT-11. What happens to the (identical) bulbs when the switch is closed?
A) A glows, B *changes*
B) A glows, B *stays same*
C) A stays same, B changes
D) A stays same, B stays same



Answer: This is a tough one! A stays the *same*, B *stays same*. After the switch is closed, the voltage on both the right and left sides of bulb A is 12V. Since there is no voltage

difference across A, no current flows through A. The voltage across bulb B is FIXED by the 12V battery that it is in parallel with.

CRKT-12.
The four light bulbs shown are identical. Which circuit puts out more total light (from both bulbs combined)? (Hint: more power = more light).

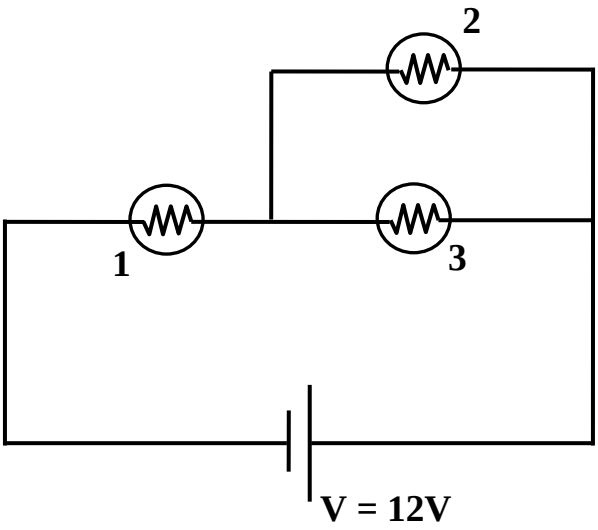


(A) (B)

(C) They both put out the same amount of light.

Answer: The total equivalent resistance which the battery in the (A) circuit sees is R/2 (two resistors, each of resistance R *in parallel*) The total equivalent resistance which the battery in the (B) circuit sees is 2R (two resistors *in series*). The total power coming from the battery is $P = \frac{V^2}{R_{tot}}$. Smaller R_{tot} (with fixed V) results in a larger power P. So (A) puts out more light.

CRKT-13.
In the circuit below, what happens to the brightness of bulb 1, when bulb 2 burns out? (When a bulb burns out, its resistance becomes infinite.)



A) Bulb 1 gets brighter

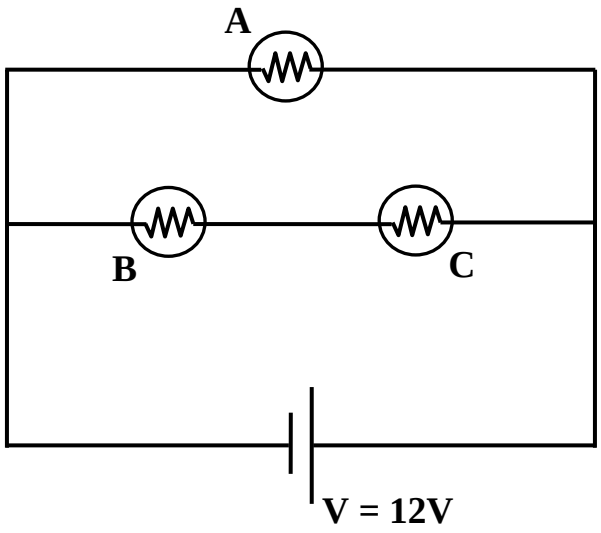
B) Bulb 1 gets dimmer.

C) Its brightness remains the same.

What happens to the total resistance of the circuit when the bulb burns out?
A) R_{tot} increases B) decreases C) stays constant

Answer: When bulb 2 burns outs, the filament inside breaks and R_2 becomes infinitely large. The total equivalent resistance which the battery sees increases (since bulb 2 is gone, there are fewer paths for the current flow, so less flow, more total resistance.) Since the battery sees a larger R_{tot}, the current from the battery $I_{tot} = V/R_{tot}$ is reduced. Less current from the battery means less current through bulb 1, less light. Bulb 1 gets dimmer.

CRKT-14.
The three light bulbs A, B, and C are identical. How does the brightness of bulbs B and C together compare with the brightness of bulb A?



A) Total power in B+C = power in A.

B) Total power in B+C > power in A.

C) Total power in B+C < power in A.

Answer: If each light bulb has the same resistance R, the series resistance of B and C is 2R. Power $P=V^2/R$. Larger total resistance for the B/C pair means less power. Total power in B+C < power in A, therefore the correct answer is C.

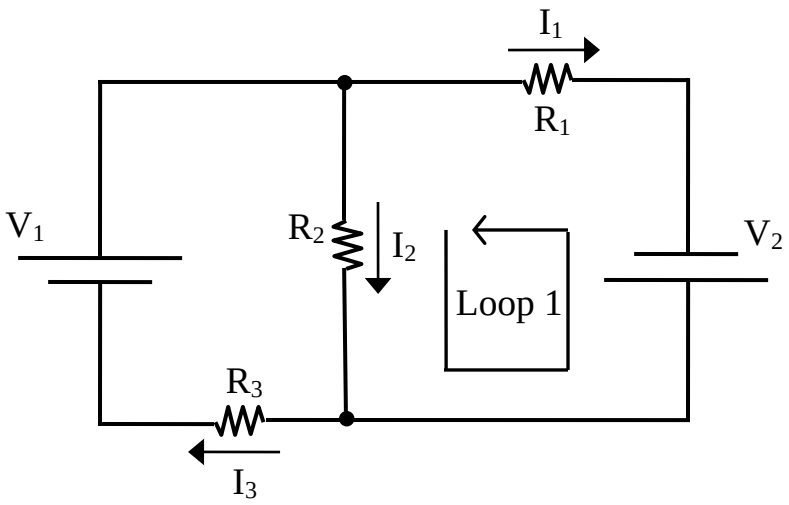
CRKT-15.
Two glowing light bulbs are in a battery-operated circuit. Light bulb A has greater resistance than light bulb B. Which light bulb is brighter?

A B C) Depends on the circuit.

Answer: Depends on the circuit. If the resistors (the light bulbs) are in series, the larger R will be brighter. But if the resistors are in parallel, the smaller R will be brighter.

CRKT-16.
A circuit with two batteries is shown below. The directions of the currents have been chosen (guessed) as shown.

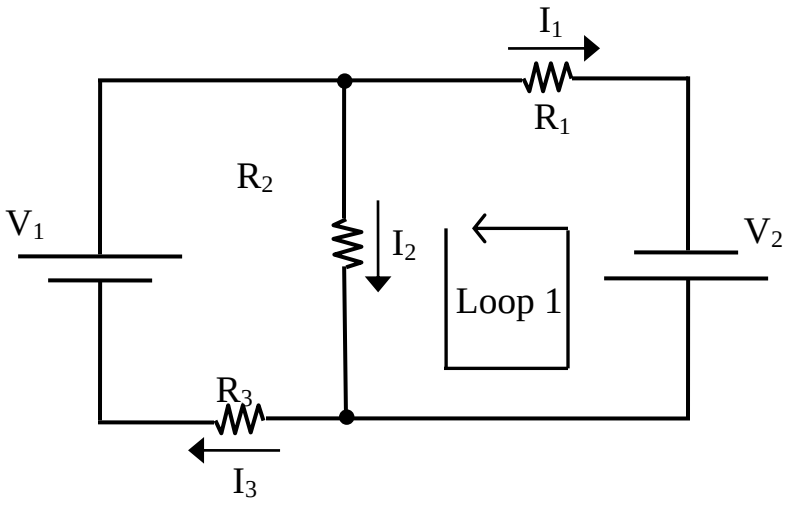
Which is the correct current equation for this circuit?
A) $I_2 = I_1 + I_3$ B) $I_1 = I_2 + I_3$ C) $I_3 = I_1 + I_2$
D) None of these.



Answer: C), $I_3 = I_1 + I_2$. Consider the upper junction (marked with a dot). The current into the junction is I_3 (current arrow pointing towards the junction means current into the junction). The current out of the junction is I_1+I_2. Kirchhoff's 2nd law says total current in equals total current out. You get exactly the same answer if you consider the lower junction.

CRKT-17. Which is the correct equation for Loop 1?

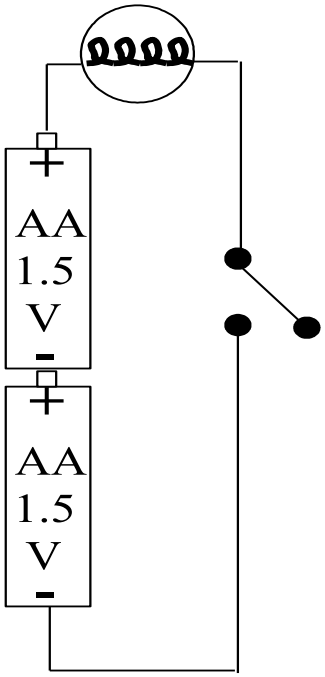
A) $-V_2 + I_1R_1 - I_2R_2 = 0$ B) $V_2 + I_1R_1 - I_2R_2 = 0$
C) $-V_2 + I_1R_1 + I_2R_2 = 0$ D) $V_2 + I_1R_1 + I_2R_2 = 0$
E) None of these.



Answer: As we move around loop 1, we go through the battery from the (+) to the (–) side, a voltage drop so the voltage change is $-V_2$. Then we go through R_1 from the low V side to the high V side (since we are moving against the current flow I_1): a voltage rise so the change is $+I_1R_1$. Finally, we go through R_2, in the same direction as the current I_2, so we have a voltage drop and a change of $-I_2R_2$. The total change as we moved around the loop must be zero, since we finished at the point where we started. $-V_2 + I_1R_1 - I_2R_2 = 0$.

CRKT-18. A flashlight requires 2 AA (1.5V) batteries, and is arranged as shown. Notice that the switch is open. Which statement is true?

A) The bulb has 1.5 V across it, and glows



B) The bulb has 3 V across it, and glows

C) The bulb has 3 V across it, and is dark

D) The bulb has 0 V across it, and is dark

E) The bulb has 0 V across it, and glows

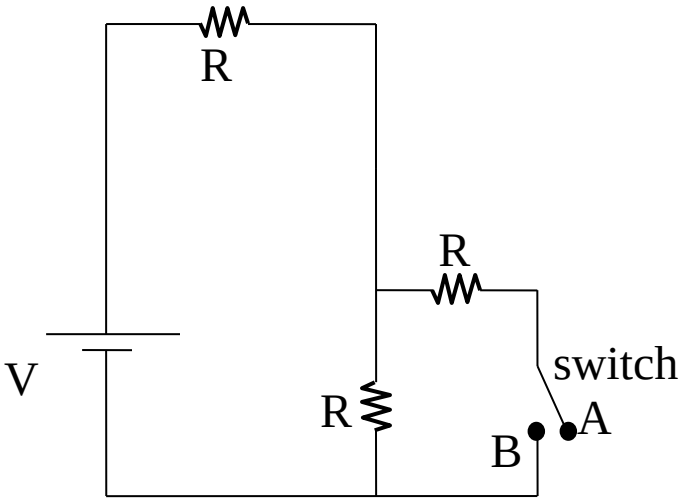
Which statement is true if the switched is closed?

Which statement is true if the switched is closed and *one* of the two batteries is reversed?

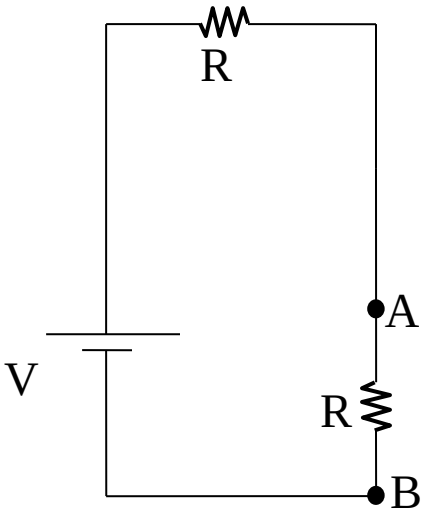
Answers: When the switch is open, the bulb has 0 V across it, and is dark.
When the switch is closed, the bulb has 3 V across it, and it glows.
If one of the batteries is reversed, and the switch is closed, the bulb has 0 V across it, and is dark.

CRKT-19. The switch in the circuit below is open. What is the magnitude of the voltage difference across the open switch? That is, what is $|V_A - V_B|$?

A) 0 B) V C) V/2 D) V/3 E) None of these



What is the magnitude of the voltage difference across the lower resistor? That is, what is $|V_A - V_B|$?



A) 0 B) V C) V/2 D) V/3 E) None of these

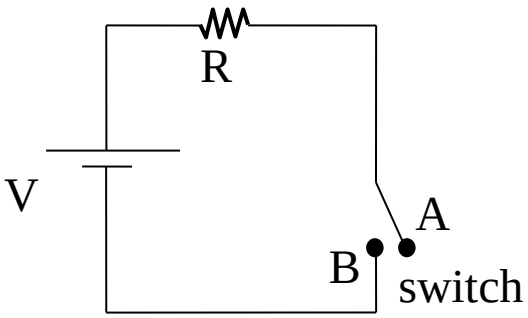
Answers: $|V_A - V_B| = V/2$ for both questions.

CRKT-20. The switch in this circuit is open. What is the magnitude of the voltage difference across the ends of the switch $|V_A - V_B|$?

A) zero

B) V

C) V/2

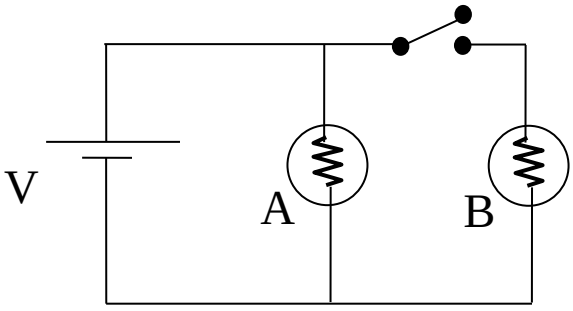


Answer: $|V_A - V_B| = V$. There is no current so the voltage change across the resistor R is zero. Therefore voltage at point A is the same as the voltage on the (+) terminal of the battery.

CRKT-21. What happens to the brightness of bulb A when the switch is closed?

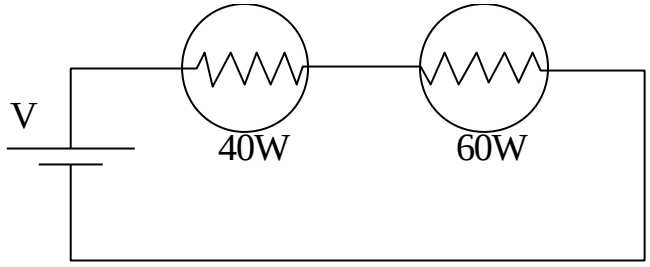
A) A gets brighter B) A gets dimmer

C) A remains the same.



Answer: A remains the same. Regardless of whether or not the switch is closed, the voltage across A is the full battery voltage V. When the switch is closed, the battery current increases, since it has to supply current to both A and B. A battery is a constant voltage device, not a constant current device.

CRKT-22.
Two light bulbs are in series attached to a battery as shown. The bulbs are marked 40W and 60W. Which bulb is brighter?
(Hints: More power = brighter. When light bulbs are ***in series,*** they have the same current. Light bulbs are intended to operate at 120V.)



A) both have same brightness

B) 40W is brighter

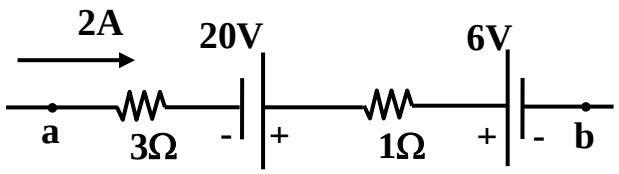
C) 60W is brighter

Which bulb has a higher resistance?

A) 40W bulb B) 60W bulb C) same resistance

Answer: This is a tricky one! The answer is that the "40W" bulb is brighter. The bulbs are labeled assuming that they would be used with a voltage of 120V. So $P_{labeled} = \frac{120V^{2}}{R}$. So IF V=120V, THEN higher R means lower P. The bulb with the smaller $P_{labeled}$ has the larger R. The "40W" bulb has higher R than the "60W" bulb. These two light bulbs are in series (and light bulbs are not intended to be used this way). In series, the current is the same, so the larger R produces the larger $P = I^2 R$.

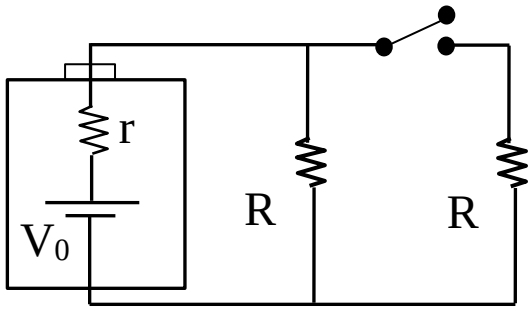
CRKT-23.
A part of a circuit is shown. What is the voltage difference ($V_a - V_b$)?



A) 6V B) 8V C) 14V
D) 20V E) 22V

Answer: 6V Imagine moving along the circuit from left to right. As we move along the voltage changes are – 6V + 20V – 2V – 6V = +6V.

CRKT-24.
A real battery, with internal resistance r and emf V_0, is attached to two identical resistors and a switch as shown.



The voltage difference between the terminals of the battery is $V_{term} = (V_{pos} - V_{neg})$. When the switch is closed, the difference between V_{term} and V_0..
A) gets bigger B) gets smaller C) remains constant.

Answer: gets bigger. When the switch is closed, more current I is drawn from the battery. The voltage between the terminals is $V_{term} = V_0 - I\,r$. So as I increases,Vterm becomes smaller and smaller.
