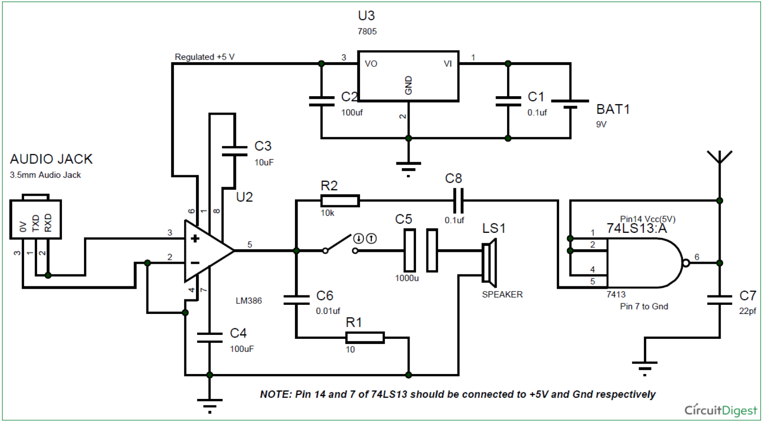
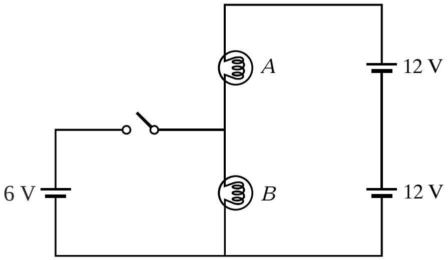
More on Kirchhoff's Rules



The light bulbs in the circuit are identical. When the switch is closed,



A. Bulb *A* is unaffected

B. The current through light bulb *B* increases

C. The current through light bulb *B* decreases

D. Bulb *B* has 2 currents going through it

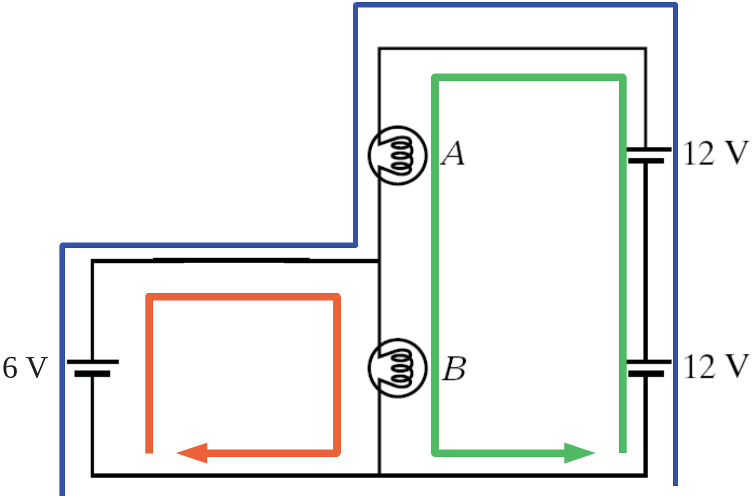
E. The potential drops across the light bulbs are equal to each other

F. More than one of the above is true

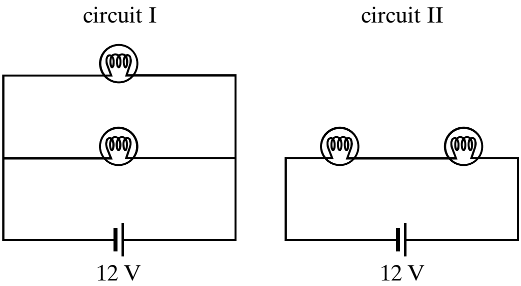
ANS: C—The current through bulb *B* decreases.

Prior to the switch closing, the potential difference across the series combination of bulbs *A* and *B* is 24 V. The same current flows through these two identical bulbs, so they will have equal potential differences. Therefore, the potential difference across each bulb is 12 V.

The diagram below shows the situation after the switch is closed.



The four light bulbs in the figure are identical. Given that brightness is proportional to power dissipated, which circuit puts out more light?



A. I

B. II

C. The two emit the same amount of light.

ANS: A—Circuit I puts out more light.

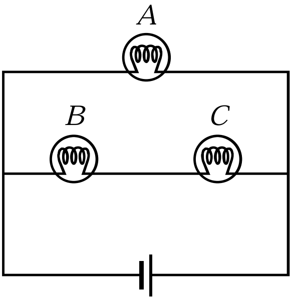
To see this, you could find the equivalent resistance of the bulbs. Let each bulb have resistance R. In I, the resistance of parallel combination is $R_\mathrm{p} = R/2$. In II, the resistance of the series combination is $R_\mathrm{s} = 2R$, *four times greater* than I. Therefore the currents delivered by the batteries are related by $I_\mathrm{I} = 4I_\mathrm{II}$. Current I_I is split between the two bulbs in I, while current I_II is the same for the two bulbs in II. Each bulb in I gets *twice* the current of each bulb II, and therefore will be brighter.

Also, consider total power delivered by the batteries as opposed to the currents through the bulbs. The power delivered by a battery is $P = I\Delta V$. Therefore, the battery in I delivers four times as much power as the battery in II. The total power put out by all bulbs in a circuit is equal to the power delivered by the battery. Therefore, the bulbs in I put out four times as much light as the bulbs in II.

Finally, consider the power dissipated by each bulb. In I, the bulbs are in parallel, so the power dissipated by each bulb in I is $\Delta V^2/R$, where ΔV is the potential difference across each bulb (and the battery). The total power dissipated in I is $P_\mathrm{I} = 2\Delta V^2/R$. In II, the potential difference across each bulb is $\Delta V/2$, so the power dissipated by each bulb is $(\Delta V/2)^2/R = \Delta V^2/(4R)$. Therefore the total power dissipated by the circuit is $P_\mathrm{II} = \Delta V^2/(2R)$.

There are even other ways to get to the final answer. All will agree that circuit I puts out more light than circuit II.

The three light bulbs in the circuit all have the same resistance. Given that brightness is proportional to power dissipated, the brightness of bulbs B and C together, compared with the brightness of bulb A, is



A. twice as much.

B. the same.

C. half as much.

ANS: **C**—Bulbs B and C together have half the brightness of A.

Because A is in parallel with the series combination of B and C, the potential difference across A will be the same as the potential difference across B and C. Therefore, the current through B and C will be half the current through A. The power through a resistor is proportional to the square of the current through it, so the power dissipated by A will be four times the power dissipated by B, and four times the power dissipated by C. Therefore, the power dissipated by B and C together will be half the power dissipated by A, or the total brightness of B and C together will be half the brightness of A.

You can also answer this question by considering the potential difference across each parallel branch. (It is the same for the A branch and for the B/C branch.) The power dissipated by all bulbs in a branch is the square of the potential difference across the branch divided by the equivalent resistance of the branch: $P = \Delta V^2/R$. Both branches have the same potential difference, but the B/C branch has twice the resistance of the A branch and therefore dissipates half as much power.