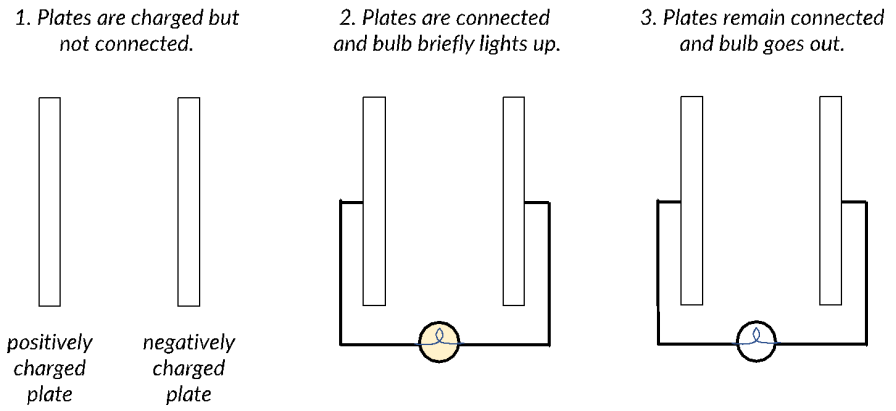
A MODEL FOR CIRCUITS

Name _____

In what follows, assume that the brightness of a lightbulb is an indicator of the current that flows through it. Also assume that all light bulbs and batteries are identical, and wires are ideal.

I. Current model

A. The figure at right shows two capacitor plates, one with a positive net charge and one with a negative net charge. When a light bulb is connected to the capacitor plates as shown, the bulb lights up momentarily and then dims and goes out.

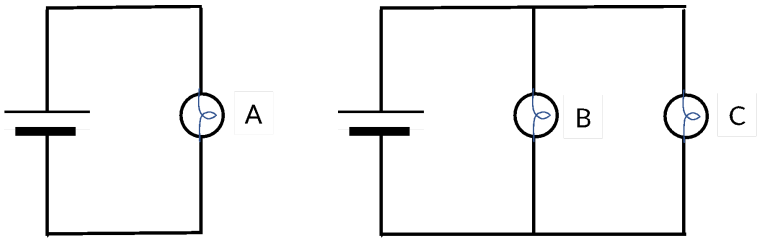


1. Describe what is happening to the charges in this scenario that makes the bulb briefly light up and then go out.

2. When a single bulb is connected to a battery as shown, why does it light and remain bright? Answer in terms of how charges move in the circuit.

In a circuit, there is a flow of charge from one side of the battery, through the circuit elements, and back to the other side of the battery. This flow of charge is called *electric current.*

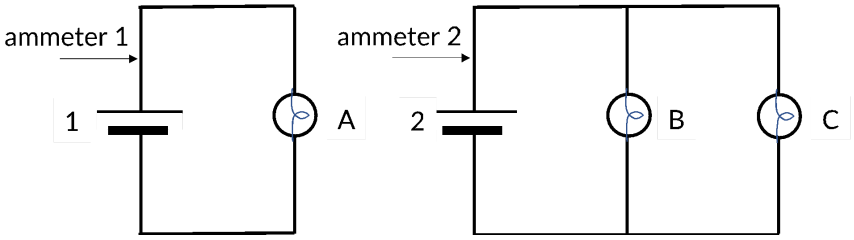
B. In the circuits at right, all three bulbs are observed to be equally bright *(A = B = C).*



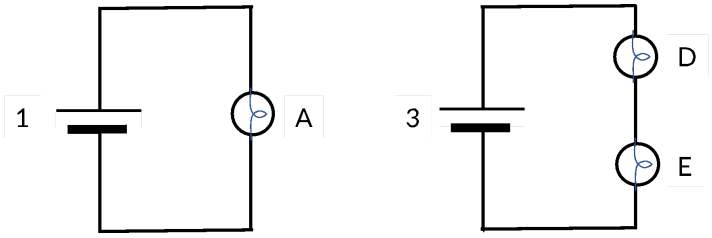
1. How does the current through bulbs *A, B,* and *C* compare? Explain why you think this is the case. Draw a diagram to show your thinking.

2. Trace the flow of current from one side of the battery, through the circuit elements, and back to the other side of the battery. Does the current split and rejoin along the circuit path? Represent this in your diagram.

3. An ammeter (a device that measures the current at a specific location in the circuit) is placed in the circuits at the location shown. Is the reading of ammeter 1 *greater than, less than,* or *equal to* the reading of ammeter 2?



C. In the circuits at right, the brightness of the bulbs is observed to compare as follows: A is the brightest, and D and E are equally bright and dimmer than A *(A > D = E).*

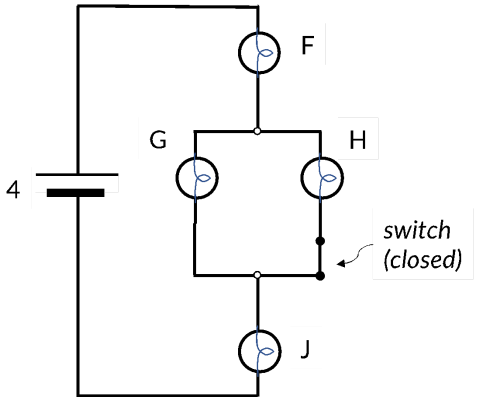


1. Why is bulb A brighter than bulb D or E? Extend the ideas you have constructed so far to explain this observation.

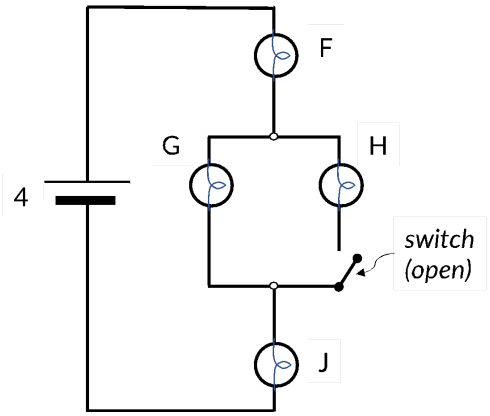
2. Why are bulbs D and E equally bright? Extend the ideas you have constructed so far to explain this observation.

3. Trace the current flow for each circuit. Choose a variety of different locations for ammeters and say how their readings would compare to each other.

D. In the circuit at right, the switch is initially closed.



1. When the switch is closed, the ranking of the brightness of the bulbs is $F = J > G = H$. Explain this observation in terms of current and show your reasoning in a diagram.



2. When the switch is opened, several changes are observed. For each observation below, explain in terms of current and show your reasoning in a diagram.

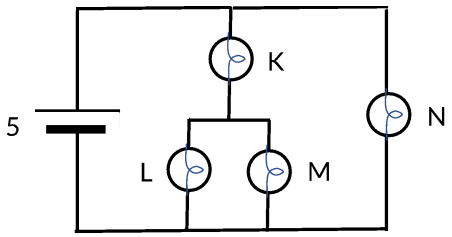
   a. Bulb *H* goes out (does not light).

   b. Bulbs *F, G,* and *J* are equally bright.

   c. Bulbs *F* and *J* are dimmer than they were when the switch was closed.

   d. Bulb *G* is brighter than it was when the switch was closed.

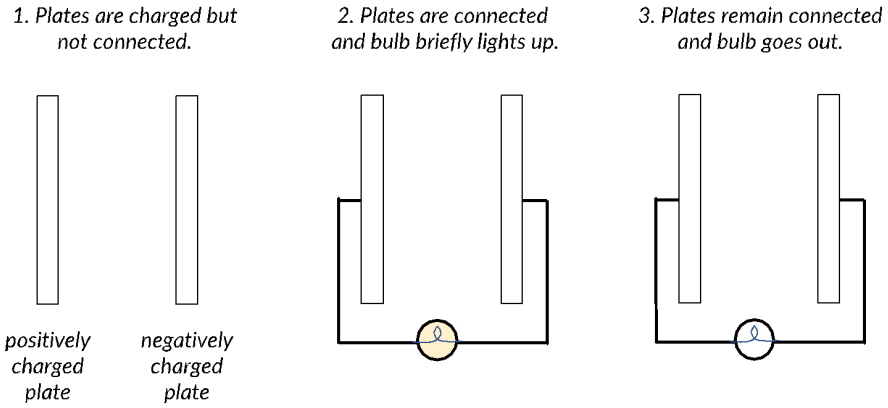
E. **Challenge problem**: Use the ideas you developed in parts A-D to rank the brightness of the bulbs in the circuit at right.



II. Voltage model

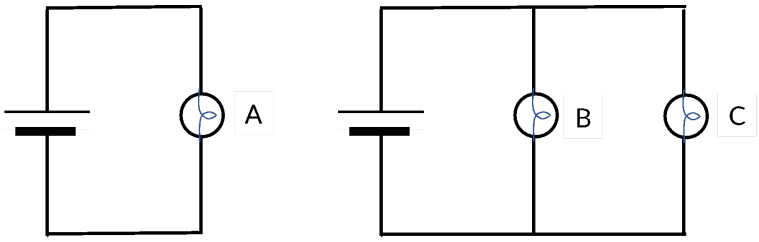
Let's return to thinking about the bulb that connects the capacitor plates.

A. Describe what is happening to the potential difference across the plates in this scenario that makes the bulb briefly light up and then go out.



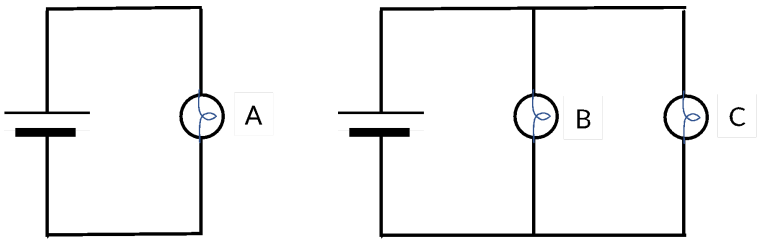
In a circuit, there is a potential difference (voltage) between the two sides of the battery, and therefore also across the circuit elements.

B. How does the potential difference across bulbs *A, B,* and *C* compare? Explain why you think this is the case. Draw a diagram to show your thinking



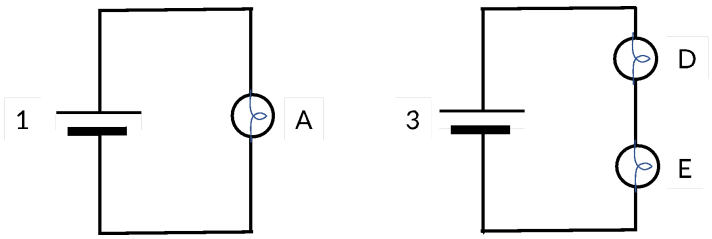
1. Map the voltages at various locations in the circuit. What locations have the same voltage? Represent this in your diagram.

2. A voltmeter (a device that measures the voltage between two points in a circuit) is used to measure the potential difference across bulbs A, B, and C. Is the reading of voltmeter A *greater than, less than,* or *equal to* the reading of voltmeter B? What about voltmeter C?



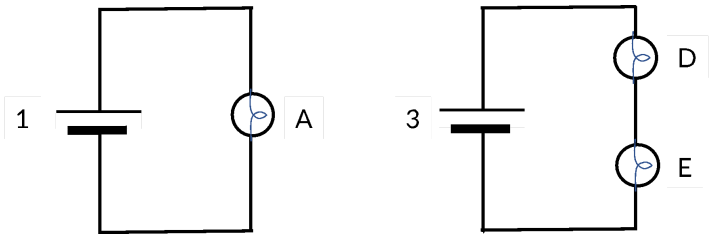
In the circuits at right, the brightness of the bulbs is observed to compare as follows: A is the brightest, and D and E are equally bright and dimmer than A *(A > D = E).*

3. Why is bulb A brighter than bulb D or E? Use your ideas about potential difference to explain this observation.



4. Why are bulbs D and E equally bright? Use your ideas about potential difference to explain this observation.

5. Map the voltages at various locations in the circuit. What locations have the same voltage? Represent this in your diagram.



II. A conceptual model for circuits

Now that you've made some observations about how circuits behave, your task is to write down a rule or set of rules for how current flows in a circuit. Your final set of rules should not only explain the observations you have already made, but also make predictions about how new circuits will behave.

A. Reflect on your responses so far: *What rule or set of rules explains why bulbs light up and how bright different light bulbs in a circuit are relative to each other?* Your rule or rules should:

- say how current splits at a junction
- say how much current flows out of and into a battery
- include other relevant electricity and magnetism ideas such as charge and potential difference
- account for your observations in the previous questions
- make predictions about the brightness of bulbs/the flow of current in more complex circuits (for example, the one at right)

Share your model with an instructor.