AP® PHYSICS 1
2016 SCORING GUIDELINES

Question 4

7 points total **Distribution of points**

(a) 3 points

Correct ranking is ($A = D$) > ($B = C$).

For indicating that the potential difference is the same across A and D because the current is the same through each (A and D are in series.) 1 point

For indicating that the potential difference is the same across B and C because B and C are in parallel 1 point

For indicating that the potential difference is less across B (and/or C) than across A (and/or D) because the current splits or the current is less through B and C 1 point

Example: The full battery current passes through both A and D, so they have the same current. Because they have the same resistance, $\Delta V_A = \Delta V_D$. B and C are in parallel, so $\Delta V_B = \Delta V_C$. Less than the full current passes through B, and A and B have the same resistance, so ΔV_B is less than ΔV_A.

(b) 2 points

Correct answer: Decrease

No points are earned if the correct answer is selected, but the explanation is completely incorrect, or there is no explanation.

If the wrong answer is selected, up to one point can still be earned.

For indicating that the effective resistance of the circuit increases 1 point

For a correct explanation of why the current through A decreases based on changes in current or potential difference throughout the circuit 1 point

Examples:

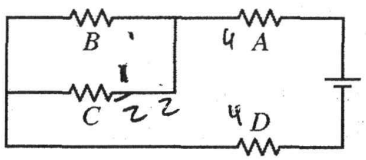
Because B is replaced with an infinite resistance, the effective resistance of the circuit increases and the battery current decreases. Because the battery current decreases and that current equals the current through A, the current through A decreases.

When B is removed, the effective resistance of that piece of the circuit increases because there is no longer a parallel combination there. Because the resistance is greater, the potential difference across that piece is a greater percent of the total. So the potential difference across A decreases and thus the current through it decreases.

Question 4 (continued)

		Distribution of points
(c)	2 points	
	Correct answer: Increase	
	No points are earned if the correct answer is selected, but the explanation is completely incorrect, or there is no explanation.	
	If the wrong answer is selected, up to one point can still be earned.	
	For indicating that all the current from the battery passes through C; the current no longer splits	1 point
	For making either a current argument or potential difference argument for the increase (i.e., an argument for why an increase in current through C more than compensates for the decrease in the full current or explaining that, by the loop rule, the potential difference across C must increase in order for the potential difference around the circuit loop to remain zero)	1 point

P1 Q4 A1



$\frac{1}{2}$ $2 = \frac{2}{\frac{1}{2}}$

$V = IR$ $\frac{1}{\frac{1}{2}} + \frac{1}{\frac{1}{2}} = \frac{1}{2}$

4. (7 points, suggested time 13 minutes)

A circuit contains a battery and four identical resistors arranged as shown in the diagram above.

(a) Rank the magnitude of the potential difference across each resistor from greatest to least. If any resistors have potential differences with the same magnitude, state that explicitly. Briefly explain your reasoning.

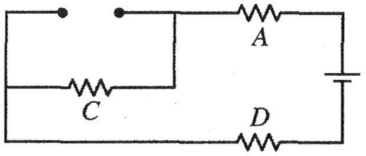
Ranking:

A has same potential difference as D. B & C are less than A & D but equal to each other

Brief explanation:

since A and D are identical resistors with the same amount of current through both of them, they have the same potential difference ($V=IR$) B and C are in a parallel structure so current gets split between them, making each of their potential differences $V = \frac{1}{2}IR$

Resistor B is now removed from the circuit, and there is no connection between the wires that were attached to it. The new circuit diagram is shown below.



(b) When resistor B is removed, does the current through resistor A increase, decrease, or remain the same?

___ Increase ___X___ Decrease (this one) ___ Remain the same

Briefly explain your reasoning.

current (I) is $\frac{\text{potential difference}}{\text{resistance}}$ $\left(I = \frac{V}{R}\right)$

When B and C where in a parallel circuit, B & C's combined resistance were less than either one of them. Therefore, if A, C, and D are all in a series there will be more resistance which equals less current.

(c) When resistor B is removed, does the current through resistor C increase, decrease, or remain the same?

___X___ Increase ___ Decrease ___ Remain the same

Briefly explain your reasoning.

when B & C where in a parallel circuit, current was split evenly between them. Current is the same for all resistors in a series, and since the removal of be creates a series circuit including C, C will get all of the current within the circuit.

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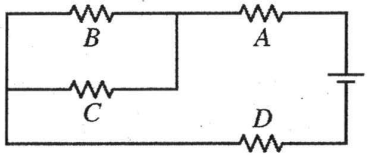
P1 Q4 B1



4. (7 points, suggested time 13 minutes)

A circuit contains a battery and four identical resistors arranged as shown in the diagram above.

(a) Rank the magnitude of the potential difference across each resistor from greatest to least. If any resistors have potential differences with the same magnitude, state that explicitly. Briefly explain your reasoning.

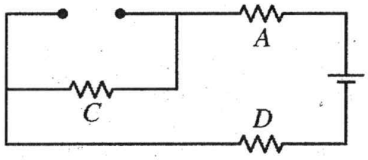
Ranking:

D=A>B=C

Brief explanation:

D and A are equal by Kirchoff's junction rule.
B and C are equal because they are in parallel. D&A are greater because they are in series with the battery and therefore receive the full total current in the circuit, unlike those in parallel.

Resistor *B* is now removed from the circuit, and there is no connection between the wires that were attached to it. The new circuit diagram is shown below.



(b) When resistor *B* is removed, does the current through resistor *A* increase, decrease, or remain the same?

X Increase ____ Decrease ____ Remain the same

Briefly explain your reasoning.

When B is removed the total resistance is decreased, the current goes up as current is indirectly proportional to resistance by $\frac{\Delta V}{\Sigma R} = I$

(c) When resistor *B* is removed, does the current through resistor *C* increase, decrease, or remain the same?

X Increase ____ Decrease ____ Remain the same

Briefly explain your reasoning.

Since C is no longer in parallel, it does not have to share current with another resistor, increasing its current

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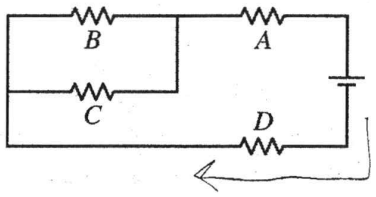
P1 Q4 C1



4. (7 points, suggested time 13 minutes)

A circuit contains a battery and four identical resistors arranged as shown in the diagram above.

(a) Rank the magnitude of the potential difference across each resistor from greatest to least. If any resistors have potential differences with the same magnitude, state that explicitly. Briefly explain your reasoning.

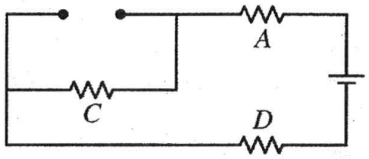
Ranking:

D > C = B > A

Brief explanation:

Since resistor D is the first resistor, all of the current must travel through it. Next, since C and B are in parallel they have equal potentials, but less than D, as some current was lost in that resistor. Lastly, resistor A is smallest because must current was lost in all the previous resistors before arriving at A.

Resistor *B* is now removed from the circuit, and there is no connection between the wires that were attached to it. The new circuit diagram is shown below.



(b) When resistor *B* is removed, does the current through resistor *A* increase, decrease, or remain the same?

____ Increase ____ Decrease X Remain the same

Briefly explain your reasoning.

As all of the current must pass through resistor A when resistor B is intact, A will have no change when B is removed. It is in series with B, unlike resistor C which is in parallel.

(c) When resistor *B* is removed, does the current through resistor *C* increase, decrease, or remain the same?

X Increase ____ Decrease ____ Remain the same

Briefly explain your reasoning.

Unlike resistor A, resistor C is in series with B, so its current will increase. Now that B is removed, resistor C will now be in series with A and D, causing it to get all the current that it was previously sharing with B.

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AP® PHYSICS 1
2016 SCORING COMMENTARY

Question 4

Overview

This question assessed learning objectives 5.B.9.3, 5.C.3.1, and 5.C.3.3. The intent of the question was to determine student understanding of series/parallel resistor circuits and the application of Ohm's law. The students were asked to analyze the effects of changes made to the circuit.

Sample: P1 Q4 A
Score: 6

In part (a) all 3 points were earned for explaining why resistors *A* and *D* have the same potential difference, and why the potential differences across resistors *B* and *C* are equal and less than that across *A* and *D*. In part (b) both points were earned for indicating that the effective resistance increases and relating this to the current. In part (c) only 1 point was earned for indicating that resistor *C* now receives the full current of the battery because the current no longer splits. However, there was no analysis or explanation showing why this increase in current more than compensates for the decrease in the overall current.

Sample: P1 Q4 B
Score: 4

In part (a) all 3 points were earned. In part (b) no points were earned because this response incorrectly indicates that the effective resistance decreases, increasing the current. In part (c) only 1 point was earned for indicating that resistor *C* now receives the full current of the battery because the current is no longer shared.

Sample: P1 Q4 C
Score: 2

In part (a) 1 point was earned for indicating that resistors *B* and *C* have the same potential difference because they are in parallel. The explanation of why *B* and *C* have a smaller potential difference than *D* is incorrect, and the ranking for resistor *A* is incorrect. In part (b) no points were earned. In part (c) only 1 point was earned for indicating that *C* now gets all the current that it was previously sharing with *B*.