

2017 SCORING GUIDELINES

Question 1

7 points total

Distribution
of points

(a) 2 points

Correct ranking: $(A = D = E) > (B = C)$ OR $A = D = E, B = C$

Note: A ranking must be given for any points to be earned for the explanation.

Note: The ranking must be correct to earn the full 2 points for the explanation.

For indicating $A = D = E$ in the ranking, with a valid explanation

1 point

Example: “A, D, and E are all connected across the battery, so they must have the same ΔV as the battery.”For indicating $B = C$ in the ranking, with a valid explanation

1 point

Example: “The same current flows through both bulbs B and C, so they have the same voltage drop across them. By Kirchhoff’s voltage rule, the sum of the voltages in this circuit must add to zero, so each bulb has half the battery voltage.”

Example 1: For each of bulbs A, D, and E, current can go around the circuit passing through only that bulb and the battery, and hence the potential drop across all three bulbs equals the voltage of the battery (because $\Delta V = 0$ for a complete loop). In circuit 2, B and C are in series so the overall potential drop (equal to the battery’s voltage) is “shared” equally between the two bulbs (because they are identical) and the potential difference across each is half is the battery’s voltage.

Example 2: A, D, and E are all connected directly across the battery terminals and therefore “get” the full battery potential difference. By contrast, the potential drop across the BC part of the circuit is “split” between B and C, and split equally.

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Question 1 (continued)

Distribution
of points

(b) 5 points

Correct answers: Circuit 3 runs out first, circuit 2 runs out last

Note: In the paragraph response, “energy dissipation” or “current” are acceptable substitutes for “power.”

For indicating that all three circuits draw different amounts of power

1 point

Note: This point may be earned by addressing only two circuits in the response.

For explaining that the battery in circuit 2 delivers the least power using correct physical reasoning by addressing potential difference OR resistance

1 point

For explaining that the battery in circuit 3 delivers the most power using correct physical reasoning by addressing potential difference OR resistance

1 point

For an implicit or explicit statement that greater power results in shorter battery life

1 point

For a logical, relevant, and internally consistent argument that addresses the required argument or question asked, and follows the guidelines described in the published requirements for the paragraph-length response

1 point

Example: The battery in circuit 3 runs out first, then the battery in circuit 1, and finally the battery in circuit 2. The power (rate of energy loss) of a battery is $P = I\Delta V$, and all three batteries have the same potential difference. So the rate of energy loss, and hence the order in which the batteries “die,” is given by the ranking of the currents through the batteries. Circuit 3 has the most current because the availability of two paths (loops) makes the overall resistance of this circuit the lowest. Circuit 2 has the least current because there is only one loop, and it contains two bulbs, making the overall resistance greater than that of circuit 1.