**Combining 1.5V batteries**

|  |  |  |
| --- | --- | --- |
|  |  |  |
| In this circuit, the bulb is lit **very brightly**. |  | Then one battery is taken away |

**1.**

* 1. What will happen now?

Put a tick (✓) in the box next to the correct answer.

|  |  |  |
| --- | --- | --- |
| **A** | The bulb gets brighter still. |  |
|  |  |  |
| **B** | The bulb stays the same brightness. |  |
|  |  |  |
| **C** | The bulb is lit, but not as bright. |  |
|  |  |  |
| **D** | The bulb is not lit. |  |

* 1. How would you explain your answer?

Put a tick (✓) in the box next to the correct answer.

|  |  |  |
| --- | --- | --- |
| **A** | The battery now has less power than before. |  |
|  |  |  |
| **B** | The battery now has less energy than before. |  |
|  |  |  |
| **C** | The voltage of one battery is less, so it pushes a smaller current round. |  |
|  |  |  |
| **D** | The resistance in the circuit is bigger, so the current is smaller. |  |

**2.** The bulbs are exactly the same type as each other. All the batteries are exactly the same as each other too.

|  |
| --- |
|  |

1. How will the brightness of the bulbs compare?

Put a tick (✓) in the box next to the correct answer.

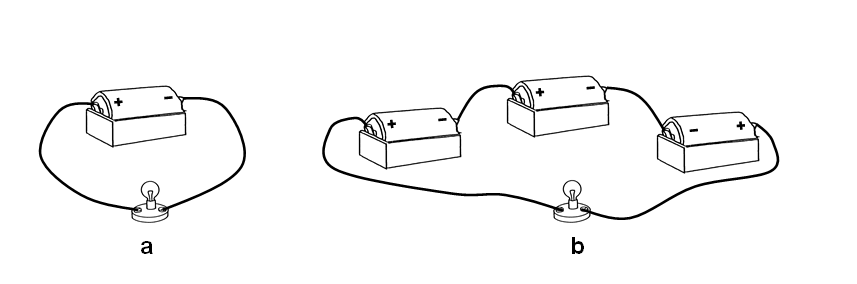
|  |  |  |
| --- | --- | --- |
| **A** | The bulb in circuit **a** will be brighter. |  |
|  |  |  |
| **B** | The bulb in circuit **b** will be brighter. |  |
|  |  |  |
| **C** | Both bulbs will be the same brightness. |  |

1. How would you explain your answer?

Put a tick (✓) in the box next to the correct answer.

|  |  |  |
| --- | --- | --- |
| **A** | Both circuits have two batteries. |  |
|  |  |  |
| **B** | The batteries in circuit **b** are opposite ways round, so they cancel each other out. |  |
|  |  |  |
| **C** | In circuit **b** the bulb is connected to two positive battery terminals, making the effect stronger. |  |

**3.** The bulbs are exactly the same type as each other. All the batteries are exactly the same as each other too.



1. How will the brightness of the bulbs compare?

Put a tick (✓) in the box next to the correct answer.

|  |  |  |
| --- | --- | --- |
| **A** | The bulb in circuit **a** will be brighter. |  |
|  |  |  |
| **B** | The bulb in circuit **b** will be brighter. |  |
|  |  |  |
| **C** | Both bulbs will be the same brightness. |  |

1. How would you explain your answer?

Put a tick (✓) in the box next to the correct answer.

|  |  |  |
| --- | --- | --- |
| **A** | Three batteries have a larger voltage than one, so they push a bigger current round. |  |
|  |  |  |
| **B** | One battery in circuit **b** is the other way round, so it blocks the current and makes the bulb in circuit **b** very dim. |  |
|  |  |  |
| **C** | One battery in circuit **b** is the other way round, so it cancels out one of the others. It works like one battery would. |  |

**4.**

|  |  |  |
| --- | --- | --- |
|  |  |  |
| In this circuit, the bulb is lit **very brightly**. |  | Then one battery is taken away. |

1. What will happen now?

Put a tick (✓) in the box next to the correct answer.

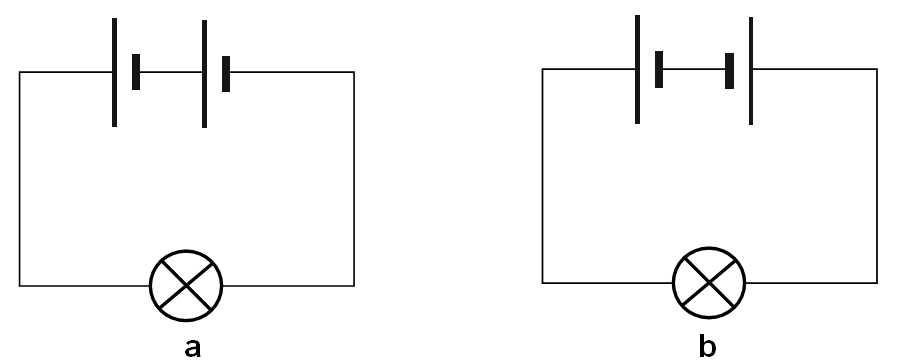
|  |  |  |
| --- | --- | --- |
| **A** | The bulb gets brighter still. |  |
|  |  |  |
| **B** | The bulb stays the same brightness. |  |
|  |  |  |
| **C** | The bulb is lit, but not as bright. |  |
|  |  |  |
| **D** | The bulb is not lit. |  |

1. How would you explain your answer?

Put a tick (✓) in the box next to the correct answer.

|  |  |  |
| --- | --- | --- |
| A | The battery now has less power than before. |  |
|  |  |  |
| B | The battery now has less energy than before. |  |
|  |  |  |
| C | The voltage of one battery is less, so it pushes a smaller current round. |  |
|  |  |  |
| D | The resistance in the circuit is bigger, so the current is smaller. |  |

**5** The bulbs are exactly the same type as each other. All the batteries are exactly the same as each other too.



1. How will the brightness of the bulbs compare?

Put a tick (✓) in the box next to the correct answer.

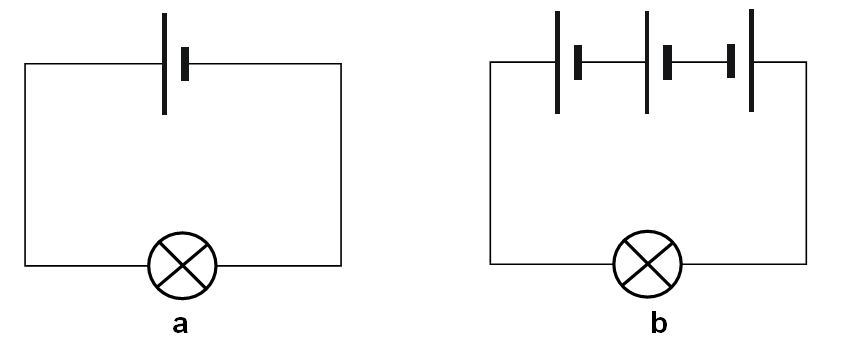
|  |  |  |
| --- | --- | --- |
| **A** | The bulb in circuit **a** will be brighter. |  |
|  |  |  |
| **B** | The bulb in circuit **b** will be brighter. |  |
|  |  |  |
| **C** | Both bulbs will be the same brightness. |  |

1. How would you explain your answer?

Put a tick (✓) in the box next to the correct answer.

|  |  |  |
| --- | --- | --- |
| **A** | Both circuits have two batteries. |  |
|  |  |  |
| **B** | The batteries in circuit **b** are opposite ways round, so they cancel each other out. |  |
|  |  |  |
| **C** | In circuit **b** the bulb is connected to two positive battery terminals, making the effect stronger. |  |

**6.** The bulbs are exactly the same type as each other. All the batteries are exactly the same as each other too.



1. How will the brightness of the bulbs compare?

Put a tick (✓) in the box next to the correct answer.

|  |  |  |
| --- | --- | --- |
| **A** | The bulb in circuit **a** will be brighter. |  |
|  |  |  |
| **B** | The bulb in circuit **b** will be brighter. |  |
|  |  |  |
| **C** | Both bulbs will be the same brightness. |  |

1. How would you explain your answer?

Put a tick (✓) in the box next to the correct answer.

|  |  |  |
| --- | --- | --- |
| **A** | Three batteries have a larger voltage than one, so they push a bigger current round. |  |
|  |  |  |
| **B** | One battery in circuit **b** is the other way round, so it blocks the current and makes the bulb in circuit **b** very dim. |  |
|  |  |  |
| **C** | One battery in circuit **b** is the other way round, so it cancels out one of the others. It works like one battery would. |  |

*Physics > Big idea PEM: Electricity and magnetism > Topic PEM1: Simple electric circuits > Key concept PEM1.3: Voltage*

|  |
| --- |
| **Diagnostic question** |
| **Combining 1.5V batteries** |

**Overview**

|  |  |
| --- | --- |
| Learning focus: | The voltage, of batteries and power supplies, is a measure of their ‘strength’. |
| Observable learning outcome: | * Apply the idea of an ‘electrical push’ to predict the effect of different series combinations of 1.5V batteries on simple circuits. |
| Question type: | Diagnostic, two-tier multiple choice |
| Key words: | Battery, voltage, current |

**What does the research say?**

Driver *et al* (1994) suggest that to develop a good understanding of voltage, it is better, at this stage, to describe it as a measure of the strength of a battery’s ‘push’ – and a bigger voltage gives a bigger ‘push’.

If students are secure in their understanding of voltage and current then adding 1.5V batteries in series is usually straightforward. However, a significant number of students have difficulty in interpreting circuit diagrams (Gott, 1984).

**Ways to use this question**

Questions 4-6 are the same as questions 1-3, but with circuit diagrams, you might decide one type of circuit representation is more appropriate for your students.

Students should complete the questions individually. This could be a pencil and paper exercise, or you could use an electronic ‘voting system’ or mini white boards and the PowerPoint presentation. The follow on question will give you insights into how they are thinking and highlight specific misunderstandings that some may hold.

If there is a range of answers, you may choose to respond through structured class discussion. Ask one student to explain why they gave the answer they did; ask another student to explain why they agree with them; ask another to explain why they disagree, and so on. This sort of discussion gives students the opportunity to explore their thinking and for you to really understand their learning needs.

You may wish to set up these circuits on the bench to demonstrate the effect after students have given their answers.

*Differentiation*

You may choose to read the questions to the class, so that everyone can focus on the science. In some situations it may be more appropriate for a teaching assistant to read for one or two students.

**Equipment**

For the class:

* four 1.5V batteries in holders
* two 3V bulb in holder
* six connecting wires

**Expected answers**

1 a C b C

2 a A b B

3 a C b C

4 a C b C

5 a A b B

6 a C b C

**How to respond - what next?**

**For questions 1 and 4** part (a): an answer of A suggests the student may be thinking that longer wires have an effect on the brightness of the bulb. B is a likely response if the student considers brightness to be just a function of the bulb (as experienced with household bulbs) or that the voltages of batteries in series do not add together. D shows the student does not fully grasp the idea of two batteries, like this, pushing twice as hard as one – so there would still be about half of the effect with one battery. (Driver *et al*, 1994)

The choices for part B should indicate which of the above misunderstandings are held if (a) is not correct. Response A would indicate an imprecise understanding/use of the key terms.

**For questions 2 and 4:** the correct answers indicate the ideas that batteries give an electrical push and that they push the current in one direction around the circuit.

(b) Answer A indicates that the student does not distinguish between each end of a battery (e.g. current is pushed out of both ends). Answer C indicates the student holds the clashing current view in which current is pushed both ways along the wire and ‘reacts’ at the bulb.

**For questions 3 and 6:** the correct answers indicate the correct use of ‘electrical push’ to predict the effect of different series combinations of 1.5V batteries.

(b) Answer A indicates that the student views batteries as a store of energy with little or no idea of how they affect the circuit. Answer B indicates that the student is not thinking in terms of each battery giving an equal sized ‘electrical push’ to the circuit.

If students have misunderstandings about adding batteries in series, it might be effective to model what is happening, or to give students practical experience in predicting and explaining measurements made when adding 1.5V batteries in series combinations. The following BEST ‘response activities’ could be used in follow-up to this diagnostic question:

* Response activity: String loop model (voltage)
* Response activity: Adding batteries (2)

With the string loop, students can model the role of the batteries in these circuits by pushing the string round in the directions indicated on the circuit diagrams.

**Acknowledgments**

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Images: EPSE

**References**

Driver R., Squires A., Rushworth P. and Wood-Robinson V. (1994). *Making sense of secondary science: research into children’s ideas* (pp.117-125). London and New York: Routledge.

Gott R. (1984). *Electricity at age 15: a report on the performance of pupils at age 15 on questions in electricity*. London: Dept. of Education and Science, Welsh Office, Dept. of Education for Northern Ireland.