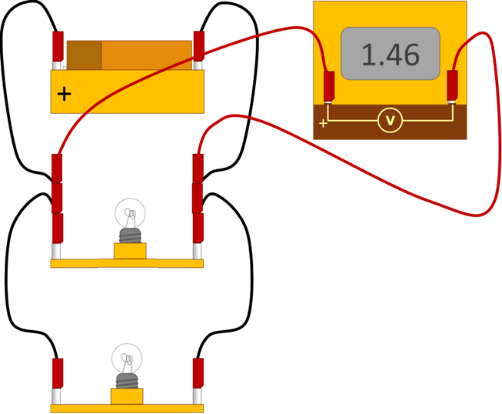
**Defining p.d.**

Potential difference (p.d.) is measured with a voltmeter.

It is measured in volts (V).

In this circuit the potential difference is being

measured across a bulb.

What happens when the potential difference across a bulb is bigger?

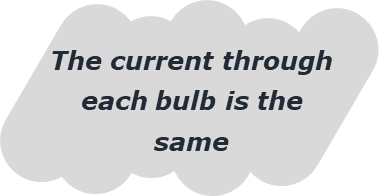


**Bulb 1**

p.d. = 230 V

current = 0.2 A

*(A household bulb)*



**Bulb 2**

p.d. = 3 V

current = 0.2 A

*(A torch bulb)*



|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| *For each statement, tick (✓)* ***one*** *column to show what you think.* | | I am **sure** this is right | I think this is right | I think this is wrong | I am **sure** this is wrong |
| **A** | The force pushing charge through bulb 1 is bigger. |  |  |  |  |
| **B** | Bulb 1 is transferring energy faster  than bulb 2. |  |  |  |  |
| **C** | More charge passes through bulb 1 each second. |  |  |  |  |
| **C** | p.d. = energy transferred ÷ charge (V = E/Q) |  |  |  |  |

*Physics > Big idea PEM: Electricity and magnetism > Topic PEM8: Mains electricity > Key concept PEM8.2: Paying for electricity*

|  |
| --- |
| **Diagnostic question** |
| **Defining p.d.** |

**Overview**

|  |  |
| --- | --- |
| Learning focus: | The amount of energy that an electrical appliance transfers is proportional to time; and its power is proportional to the potential difference across it *and* the current through it. |
| Observable learning outcome: | Explain the relationships I = Q/t and V = E/Q. |
| Question type: | Confidence grid |
| Key words: | Potential difference, energy, charge, voltmeter, volt, coulomb, joule |

**What does the research say?**

The understanding of why power can be calculated using P = I x V begins with the understanding of electric current as a flow of charge. This leads on to the introduction of relationship I = Q/t as a shorthand way of writing this down and of quantifying currents for comparison (Hartley, Fairhurst and Norris, 2021). The next step is to understand that potential difference is linked to energy because it (causes an electromagnetic field that) provides an electrical ‘push’.

With a bigger potential difference across a component, electric charges are ‘pushed’ harder which means they can do work at a higher rate (Hartley et al., 2021). The equation V = E/Q represents this relationship and shows that when the potential difference pushing a certain amount of charge through a component is doubled (or tripled etc.), then two times the amount of energy is shifted – because with two times the ‘push’ on the same charge, the charge can do work at twice the rate.

Both I = Q/t and V = E/Q are derived from a microscope model of current that comprises charged particles caused to move by forces due to an electric field and impeded by collisions with microscopic structures and particles in a conductor (Liu et al., 2022). The two equations can be combined (I x V = Q/t x E/Q = E/t = P) to show that P = I x V; and the microscopic model of current used to explain the relationship.

**Ways to use this question**

Students should complete the confidence grid 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.

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.

*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.

**Expected answers**

Statements A, B and D are right; and statement C is wrong.

**How to respond - what next?**

The bigger the potential difference across a component, the bigger the electromagnetic force pushing charge through it. The bigger the force on the electric charges, the more quickly they can do work and the more energy they can transfer to a component. In fact, the force on the electric charges in a component is proportional to the p.d. across it.

From the definition of a volt, the potential difference (p.d.) across a component is equal to the energy transferred by each unit (coulomb) of charge passing through it.

A Most students are likely to think correctly that a bigger p.d. causes the forces pushing charge through a bulb to be bigger. However, some students may not think of potential difference as causing a pushing force on the charges. They may perhaps think of voltage as a quantity of energy to be used up by a bulb and that bulb 1 simple uses it up more quickly.

B It is likely that (almost) all students will understand that bulb 1 transfers energy more quickly because it emits a brighter light.

C It is likely that some students will connect a bigger force pushing electric charges with a faster movement through the bulb and wrongly think that this statement is correct. Instead, they need to recognise that because the current through each bulb is the same, the charge flows through each one at the same rate. (In this example, bulb 1 has a bigger resistance than bulb 2.)

D If students have answered the previous three statements correctly, they may apply logic to realise that this statement could be correct (although the observations made do not *prove* that it is correct) – the best box to tick for this choice may therefore be ‘I think this is right’.

If students have misunderstandings about the definition of p.d., it can help to provide students with an opportunity to review their understanding of the relationship between energy and potential difference for a fixed current. This could perhaps be done by using a rope-loop model.

The following BEST ‘response activity’ could be used in follow-up to this diagnostic question:

* Response activity: Dotty rope

**Acknowledgments**

Developed by Peter Fairhurst (UYSEG).

Images by Peter Fairhurst (UYSEG), and light bulbs by Clker-Free-Vector-Images from Pixabay.

**References**

Hartley, R., Fairhurst, P. and Norris, T. (2021). Electricity and magnetism. In de Winter, J. & Hardman, M. (eds.) *Teaching secondary physics.* 3rd ed. London: Hodder Education.

Liu, Z., et al. (2022). Assessment of knowledge integration in student learning of simple electric circuits. *Physical Review Physics Education Research,* 18(2)**,** 020102.