AQA

A Level

A Level Physics

ELECTRICAL CIRCUITS: Electrical Quantities (Answers)

Name:

MME

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Total Marks: /30

1. This question is about the variation of quantities such as current, voltage and resistance in simple electrical circuits containing a variety of standard components.

Total for Question 1: 11

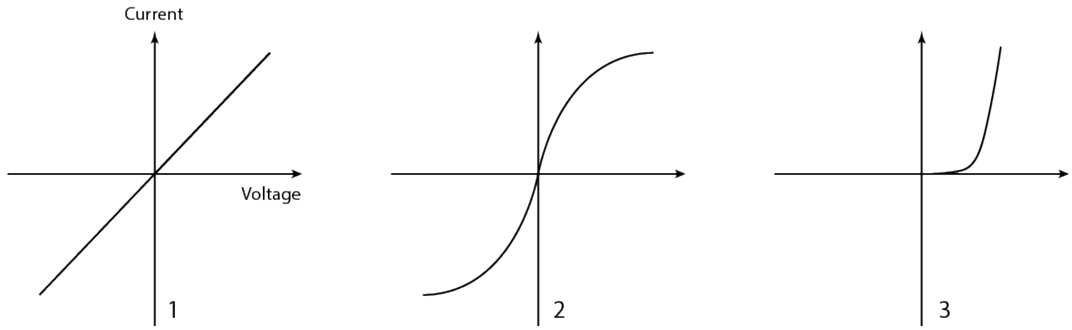

Figure 1: I-V characteristics for three different circuit components.

(a) State Ohm's Law. [1]

Solution: $I \propto V$

(b) Assign one of the following components to each of the characteristic graphs in Figure 1: filament lamp, semiconductor diode, resistor. [3]

Solution:
1: resistor
2: filament lamp
3: diode

(c) Why have these been plotted on graphs of current against potential difference rather than current against electromotive force? [1]

Solution: EMF is concerned with energy being put into the circuit; PD is concerned with energy used by components.

(d) For the diode, state the value of the resistance when a backward bias is applied. [1]

Solution: Zero

(e) Sketch the following graphs: [2]

i. Resistance against temperature for an ntc thermistor.

ii. Current against voltage for an ntc thermistor.

Solution:
(i) Non-linear decrease of resistance as temperature increases. Concave up.
(ii) inverse of the filament lamp i.e. concave up in the positive quadrant and concave down in the negative quadrant.

(f) The current in a filament is 8 A. In the time during which Patrick is using the lamp, 8×10^{22} electrons pass through a given point in the circuit. For how long has he been using the lamp? [3]

Solution: 1600 s

2. James unexpectedly finds an electrical circuit in his physics classroom. Immediately he starts recording the current. He notes that it decreases linearly from 10 A to zero over a time period of 30 s.

Total for Question 2: 5

(a) Plot a graph of current against time. [2]

Solution: As described.

(b) Calculate the charge that is transferred in this time. [2]

Solution: 150 C

(c) If James had also been able to record a graph of charge (vertical axis) against time (horizontal axis), which of the following accurately describes what he would have seen? [1]

i. Linear increase.
ii. Non-linear increase.
iii. Linear decrease.

Solution: Option 2.

3. Frances is exploring the electrical properties of a piece of wire. She observes that:
(a) for a given current, doubling the length, L, of the wire doubles the potential difference (P.D.) and the resistance, R.
(b) for a given P.D., doubling the wire's diameter, d, causes R to decrease by a factor of 4.

Total for Question 3: 11

(a) On the basis of Frances' observations, which of these relationships is true: [3]

i. $R \propto A$ and $R \propto L$
ii. $R \propto 1/A$ and $R \propto 1/L$
iii. $R \propto 1/A$ and $R \propto L$
iv. $R \propto d^2$ and $R \propto L$

Solution: Option 3.

(b) Use this to define resistivity, ρ, in terms of d, R and L. [2]

Solution: $\frac{\pi d^2 R}{4L}$

(c) Figure 2 is a characteristic graph for a circuit component. Calculate the resistivity at the point for which the curves tangent has been drawn given that the component is cylindrical, has a length of 8 cm and has a radius of 1.5×10^{-5} m. [3]

Solution: 1.8×10^{-8}

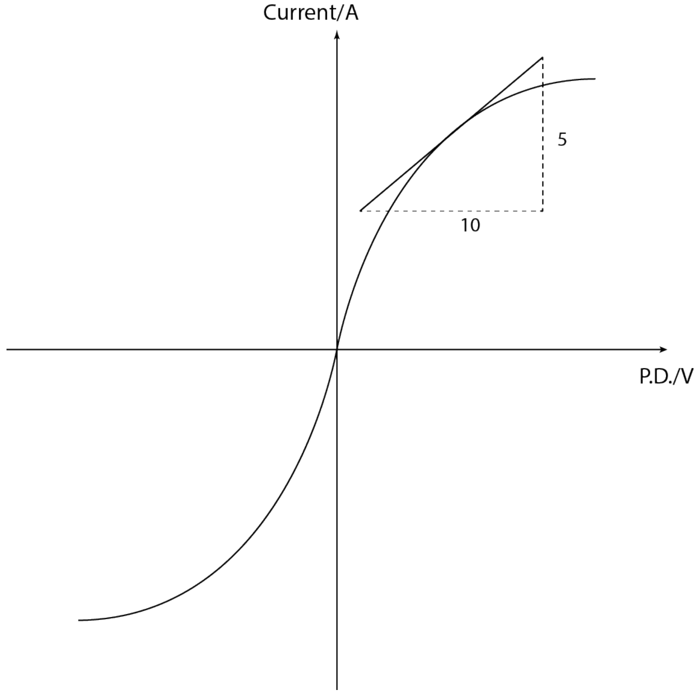

Figure 2: Characteristic graph for a particular circuit component.

(d) Explain how, using the characteristic, it is possible to deduce that, for this component, resistivity increases with temperature. [3]

Solution: As temperature increases, so too does current. But, on the characteristic, as current increases the gradient decreases i.e. R increases. Since $\rho = \frac{AR}{L}$, if R increases but the dimensions remain unchanged, ρ will also increase.

4. This question is about superconductors.

Total for Question 4: 3

(a) A superconductor is a material whose resistance... [1]

i. ... increases to ∞ below a specific critical temperature.

ii. ... decreases to zero above a specific critical temperature.

iii. ... decreases to zero below a specific critical temperature.

Solution: Option 3.

(b) At present the highest known critical temperature is approximately -130°C. Give two examples that illustrate why a superconductor with a room temperature critical temperature would be particularly useful. [2]

Solution: Any valid examples e.g. long-lasting batteries, heat-free laptops.