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QUESTION WORKBOOK

Resistivity and superconductivity

Electricity · Year 12

AQA 3.5.1.3 · CIE 9.3.6, 9.3.8 · OCR A 4.2.4(a)(i), 4.2.4(a)(ii), 4.2.4(b), 4.2.4(c)

18 questions · 58 marks

NAVY SCREEN EDITION

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SECTION A · Warm-up

A1 State the equation relating the resistance of a wire to its resistivity, and give the unit of resistivity. [2]

A2 A copper wire (resistivity $1.7 \times 10^{-8}\ \Omega\ m$) has length 2.0 m and cross-sectional area $1.0 \times 10^{-6}\ m^2$. Calculate its resistance. [2]

A3 State what is meant by superconductivity. [2]

A4 State how the resistance of an ntc thermistor changes as its temperature rises, and give one practical use of a thermistor. [2]

A5 A uniform wire of resistance 3.2 Ω is cut into two equal lengths. State the resistance of each half. [1]

SECTION B · Standard

B1 A wire of length 1.5 m and diameter 0.40 mm has a resistance of 0.50 Ω. Calculate (a) its cross-sectional area and (b) the resistivity of its material. [4]

B2 A wire of resistivity 2.8×10^{-8} Ω m and cross-sectional area 2.0×10^{-6} m^2 is to have a resistance of 0.10 Ω. Calculate the length required. [3]

B3 A wire's length is doubled and its cross-sectional area is halved. State the factor by which its resistance changes, and explain why. [3]

B4 Describe qualitatively how the resistance of a metal wire changes as its temperature increases, and why. [3]

B5 A heater manufacturer needs a 1.2 m length of nichrome wire (resistivity 1.1×10^{-6} Ω m) to have a resistance of 15 Ω. Calculate the diameter of wire required. [4]

B6 The mass of a 4.00 m length of copper wire is 2.85 g. The density of copper is 8930 kg m^{-3} and its resistivity is 1.7×10^{-8} Ω m. Calculate (a) the cross-sectional area of the wire and (b) its resistance. [4]

B7 The main coil of an MRI scanner carries a current of 480 A and is normally superconducting. During a fault the coil warms above its critical temperature and develops a resistance of 0.25 Ω. Calculate the power dissipated in the coil during the fault, and state the power dissipated during normal operation. [3]

SECTION C · Stretch

C1 Two wires are made of the same material. Wire B has twice the length and twice the diameter of wire A. If wire A has a resistance of 8.0 Ω, calculate the resistance of wire B. [4]

C2 A heating element is made from wire of resistivity 1.1×10^{-6} Ω m, length 5.0 m and cross-sectional area 2.0×10^{-7} m^2. Calculate its resistance and its power when connected to a 230 V supply. [4]

C3 Describe what happens to a superconductor at its critical temperature and give one practical use of superconductors. [3]

C4 A student needs a 2.0 m length of wire with a resistance between 4.5 Ω and 5.5 Ω. Four reels are available. Wire W: copper ($\rho = 1.7 \times 10^{-8}$ Ω m), diameter 0.25 mm. Wire X: constantan ($\rho = 4.9 \times 10^{-7}$ Ω m), diameter 0.50 mm. Wire Y: constantan, diameter 0.25 mm. Wire Z: nichrome ($\rho = 1.1 \times 10^{-6}$ Ω m), diameter 0.50 mm. Deduce which wire the student should use. [4]

C5 A metal wire and an ntc thermistor happen to have the same resistance at 20 °C. Both are then warmed to 80 °C. Compare what happens to the resistance of each, explaining both changes in terms of the charge carriers and the lattice. [6]

C6 A student measures the resistance R of several different lengths L of the same wire and plots R against L, obtaining a straight line through the origin with gradient 2.4 Ω m^{-1}. The wire's diameter is 0.20 mm. Determine the resistivity of the wire's material.

[4]