



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

PRINT EDITION

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 $1.7 \times 10^{-8} \Omega \text{ m}$) has length 2.0 m and cross-sectional area $1.0 \times 10^{-6} \text{ m}^2$. 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 3.2Ω 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 $2.8 \times 10^{-8} \Omega \text{ m}$ and cross-sectional area $2.0 \times 10^{-6} \text{ m}^2$ 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 $1.1 \times 10^{-6} \Omega \text{ m}$) 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 $1.7 \times 10^{-8} \Omega \text{ m}$. 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 $8.0 \, \Omega$, calculate the resistance of wire B. [4]

- C2** A heating element is made from wire of resistivity $1.1 \times 10^{-6} \, \Omega \, \text{m}$, length $5.0 \, \text{m}$ and cross-sectional area $2.0 \times 10^{-7} \, \text{m}^2$. Calculate its resistance and its power when connected to a $230 \, \text{V}$ 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 ($\rho = 1.7 \times 10^{-8} \Omega \text{ m}$), diameter 0.25 mm. Wire X: constantan ($\rho = 4.9 \times 10^{-7} \Omega \text{ m}$), diameter 0.50 mm. Wire Y: constantan, diameter 0.25 mm. Wire Z: nichrome ($\rho = 1.1 \times 10^{-6} \Omega \text{ m}$), 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 $^{\circ}\text{C}$. Both are then warmed to 80 $^{\circ}\text{C}$. 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 $2.4 \, \Omega \, \text{m}^{-1}$. The wire's diameter is $0.20 \, \text{mm}$. Determine the resistivity of the wire's material.

[4]