InkPhysics

ANSWER BOOK

Resistivity and superconductivity

Electricity · Year 12

AQA 3.5.1.3 · CIE 9.3 · OCR A 4.2.4

10 questions · 30 marks

NAVY EDITION

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SECTION A · Warm-up

A1 $R = \rho L/A$, where ρ is the resistivity, L the length and A the cross-sectional area. Resistivity has the unit ohm metre (Ω m). [1]

A2 $R = \rho L/A = (1.7 \times 10^{-8} \times 2.0)/(1.0 \times 10^{-6}) = 0.034\ \Omega$. [2]

A3 Below a critical temperature the resistivity of a superconductor falls to zero, so it conducts electricity with no resistance and no energy dissipated. [2]

SECTION B · Standard

B1 (a) $A = \pi(d/2)^2 = \pi \times (0.20 \times 10^{-3})^2 = 1.26 \times 10^{-7}\ m^2$. (b) $\rho = RA/L = (0.50 \times 1.26 \times 10^{-7})/1.5 = 4.19 \times 10^{-8}\ \Omega$ m. [4]

B2 $L = RA/\rho = (0.10 \times 2.0 \times 10^{-6})/(2.8 \times 10^{-8}) = 7.14$ m. [3]

B3 Resistance increases by a factor of 4. From $R = \rho L/A$, doubling L doubles R and halving A doubles R again, giving $2 \times 2 = 4$ times the original resistance. [3]

B4 The resistance increases. Higher temperature makes the metal ions vibrate more, so the conduction electrons collide with them more often, impeding their flow and raising the resistance. [3]

SECTION C · Stretch

C1 Doubling the diameter multiplies the area by 4. $R = \rho L/A$, so $R_B = R_A \times (2)/(4) = 8.0 \times 0.5 = 4.0\ \Omega$. [4]

C2 $R = \rho L/A = (1.1 \times 10^{-6} \times 5.0)/(2.0 \times 10^{-7}) = 27.5\ \Omega$. $P = V^2/R = 230^2/27.5 = 1924$ W. [4]

C3 As it is cooled to its critical temperature the resistivity suddenly drops to zero. Uses include the powerful electromagnets in MRI scanners and particle accelerators, and lossless power transmission cables. [3]