On resistivity

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Warm-up problems

1. Explain what is meant by the term *electrical resistivity*, and show that its unit is $\Omega\,\mathrm{m}$?

2. What makes it more useful than *resistance*? *(Hint: use the analogy between* resistance / resistivity *and* mass / density*.)*

3. Find the length of constantan wire, radius $5.0 \times 10^{-2}\,\mathrm{cm}$, needed to make a $3.0\,\Omega$ resistor. ($\rho = 4.9 \times 10^{-7}\,\Omega\,\mathrm{m}$)

Regular problems

4. A block of carbon, 1.0 cm by 2.0 cm by 5.0 cm, has a resistance of $0.015\,\Omega$ between its two smaller faces. What is the resistivity of carbon?

5. A piece of wire has a resistance, R. What will be the resistance of a wire of the same material which is three times as long and twice as thick?

6. 3.0 m of iron wire of uniform diameter 0.80 mm has a potential difference of 1.50 V across its ends. Calculate the current in the wire. ($\rho_{\mathrm{Fe}} = 9.7 \times 10^{-8}\,\Omega\,\mathrm{m}$)

7. A piece of lead wire is connected in parallel with a piece of iron wire of the same diameter but twice as long. If a current of 0.90 A flows through the combination. Find the current in each wire. ($\rho_{\mathrm{Fe}} = 9.7 \times 10^{-8}\,\Omega\,\mathrm{m}$, $\rho_{\mathrm{Pb}} = 2.1 \times 10^{-7}\,\Omega\,\mathrm{m}$).

8. In 1881, the ohm was made a base unit (rather than a derived unit like it is today). The 'practical ohm' was defined (at a conference in 1893) as being represented by a column of mercury of cross-section $1\,\mathrm{mm}^2$ at the temperature of melting ice, having length 106.300 cm and mass 14.5421 g.

   (a) What is the density of mercury?

   (b) What is its resistivity?

   (c) How accurately was the ohm defined at this time? (i.e. 1 part in 100, 1 part in 100 000...)

9. A wire of uniform cross-section has a resistance of R. If it is drawn to three times the length, but the volume remains constant, what will be its resistance?

Extension problems

10. (from Nelkon & Parker, *Advanced Level Physics*) A thin film resistor in a solid state circuit has a thickness of 1 µm and is made of nichrome of resistivity $10^{-6}\,\Omega\,\mathrm{m}$. Calculate the resistance available between opposite edges of a $1\,\mathrm{mm}^2$ area of film

    (a) if it is square shaped,

    (b) if it is rectangular, 20 times as long as it is wide.

11. The 1861 ohm was chosen to be 10^9 abΩ [*Nature* Vol. 24, 512 (1881)], in order to be a convenient size, because the abΩ in use at the time was very small. The original abΩ was defined in 1838 for electrical usage from the 'ohmad'. This ohmad was in turn defined as the resistance of one foot of number 11 copper wire (which has diameter 0.0907 inch). A definition based on familiar wires was natural at the time, as the telegraph was critically affected by the resistance of its wires, which set the interval at which repeater stations had to be provided. The resistivity of copper is 6.58×10^{-7} ohm-inch. How big was the original ohmad in modern Ω?