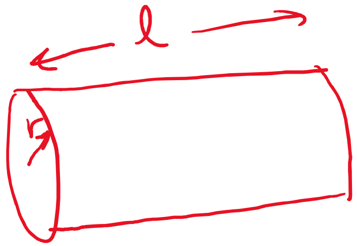
Q1 M2-122-19

A cylindrical resistor of radius 2.5 mm and length 4.0 cm is made of a material that has a resistivity of $3.5\times10^{-5}\ \Omega.\ \text{m}$. What is the potential difference when the energy dissipation rate in the resistor is 1.0 W?

A) 0.27 V
B) 1.8 V
C) 2.2 V
D) 0.17 V
E) 1.1 V



$$P = \frac{V^2}{R} = \frac{V^2}{\frac{\rho l}{A}} = \frac{V^2 A}{\rho l} = \frac{V^2 \pi r^2}{\rho l}$$

$$V = \sqrt{\frac{P\rho l}{\pi r^2}} = \sqrt{\frac{1\times3.5\times10^{-5}\times0.04}{\pi}}\ \frac{1}{2.5\times10^{-3}} = 0.27\ \text{V}$$

Q2 M2-122-20

A 1.0-m-long wire has a resistance equal to 0.30 Ω. A second wire made of identical material has a length of 2.0 m and a mass equal to the mass of the first wire. What is the resistance of the second wire?

A) 1.2 Ω
B) 1.0 Ω
C) 3.4 Ω
D) 4.3 Ω
E) 5.6 Ω

same mass ⇒ same volume

$$V_1 = A_1 l_1 = A_2 l_2 \Rightarrow A_2 = A_1 \frac{l_1}{l_2} = \frac{A_1}{2}$$

$$R_2 = \rho \frac{l_2}{A_2} = \rho \frac{2 l_1}{\frac{A_1}{2}} = 4 \rho \frac{l_1}{A_1} = 4 R_1 = 1.2\ \Omega$$

Q3 M2-132-19

The resistance of a wire at 0°C is 70.0 Ω. If temperature of the wire increases to 100° C, its resistance increases by 50 %. What is resistance of the wire at 120°C? (Ignore changes in the dimensions of the wire)

A) 112 Ω
B) 211 Ω
C) 101 Ω
D) 181 Ω
E) 150 Ω

$$R - R_0 = \alpha R_0 (T - T_0)$$

$0^\circ C \rightarrow 100^\circ$ $\Rightarrow \frac{R_{100} - R_0}{R_0} = 0.5 = \alpha (T_{100} - T_0)$

$$\frac{R_{120} - R_0}{R_0} = \alpha (T_{120} - T_0)$$

$$\frac{\frac{R_{120} - R_0}{R_0}}{0.5} = \frac{T_{120} - T_0}{T_{100} - T_0}$$

$$R_{120} = R_0 \left(1 + 0.5 \frac{T_{120} - T_0}{T_{100} - T_0}\right)$$

$$= 70 \left(1 + 0.5 \frac{120}{100}\right) = 70(1.6) = 112 \Omega$$

Q4 M2-132-20

A copper wire of cross-sectional area 2.00×10^{-6} m^2 and length 4.00 m has a current of 2.00 A uniformly distributed across its area. How much electrical energy is transferred into thermal energy in 1.00 hour (resistivity of copper = 1.69×10^{-8} Ω.m)

A) 487 J
B) 319 J
C) 727 J
D) 559 J
E) 996 J

$$\text{Power} = \frac{\text{Electrical energy}}{\text{time}}$$

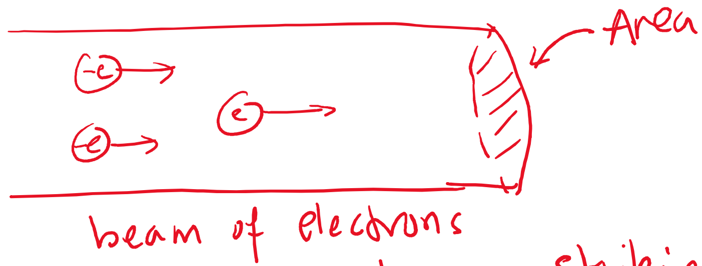
$$\text{Electrical energy} = (\text{Power})(\text{time}) = (i^2 R)t = i^2 \frac{\rho l}{A} t$$

$$= (2)^2 \frac{1.69 \times 10^{-8} \times 4}{2 \times 10^{-6}} \times 60 \times 60 = 487 \text{ J}$$

Q5 M2-142-19

A continuous beam of electrons, of current 125 mA, is incident on a target. How many electrons strike the target in a period of 23.0 s?

A) 1.80×10^{19}
B) 1.37×10^{19}
C) 7.21×10^{19}
D) 2.16×10^{19}
E) 1.56×10^{19}



$$\text{current} = \frac{\text{net charge striking the area}}{\text{time}}$$

$$i = \frac{q}{t} \Rightarrow q = it$$

$$\#\text{ of electrons striking the area} = \frac{\text{Net charge striking the area}}{\text{charge of an electron}}$$

$$= \frac{it}{e} = \frac{(0.125)(23)}{1.6\times10^{-19}} = 1.80\times10^{19}\text{ electrons}$$

Q6 M2-142-20

A light bulb, has a resistance of 15 Ω, is connected between the terminals of a 120 V source. If the temperature is not ignored, which one of the following answers can be the expected output power of the bulb?

A) 840 W
B) 950 W
C) 1000 W
D) 1800 W
E) 5000 W

$$R - R_0 = R_0 \alpha (T - T_0)$$

$$R = R_0 (1 + \alpha (T - T_0))$$

x

when a bulb is on, its temperature becomes larger than the room temperature.

$$T > T_0$$

$$R = R_0 x > R_0$$

$$\text{Power} = \frac{V^2}{R} = \frac{V^2}{R_0 x} = \frac{120^2}{15^2 x} = \frac{960\text{ W}}{x} < 960\text{ W}$$

Q7 M2-142-18

At what temperature will aluminum have a resistivity that is three times the resistivity that of copper has at 20 °C? At 20 °C, the resistivity of aluminum is 2.75×10^{-8} Ω.m and the resistivity of copper is 1.69×10^{-8} Ω·m. The temperature coefficient of aluminum $\alpha_{Al} = 4.4\times10\text{-}3\ K^{-1}$.

A) 212 °C
B) 250 °C
C) 130 °C
D) 600 °C
E) 420 °C

Copper → $3\rho_{co}$

$$\rho_A - \rho_{Ao} = \rho_{Ao}\alpha_A(T - T_o)$$

↑ Aluminum

$$3\rho_{co} - \rho_{Ao} = \rho_{Ao}\alpha_A(T - T_o)$$

$$T = T_o + \frac{3\rho_{co} - \rho_{Ao}}{\rho_{Ao}\alpha_A} = 20 + \frac{3(1.69\times10^{-8}) - 2.75\times10^{-8}}{(2.75\times10^{-8})(4.4\times10^{-3})} = 212^{\circ}C$$