Answer on Question 58123, Physics, Other

Question:

5. The temperature at which the tungsten filament of a $12\ V$ and $36\ W$ lamp operates is 1730 ℃. If the temperature coefficient of resistance of tungsten is $6 \cdot 10^{-3}\ 1/K$, find the resistance of the lamp at a room temperature of 20 ℃:

a) $10.00\ \Omega$

b) $0.45\ \Omega$

c) $0.39\ \Omega$

d) $4.0\ \Omega$

Solution:

Let's first find the resistance of tungsten filament at temperature 1730 ℃. From the definition of the electrical power we have:

$$P = \frac{V^2}{R}.$$

From this formula we can find the resistance of tungsten filament at temperature 1730 ℃:

$$R = \frac{V^2}{P} = \frac{(12\ V)^2}{36\ W} = 4\ \Omega.$$

We can find the resistance of the lamp at a room temperature of 20 ℃ from the formula:

$$R = R_{ref}\left[1 + \alpha\left(T - T_{ref}\right)\right],$$

here, R is the resistance of tungsten filament at temperature 1730 ℃ (or $2003.15\ K$), R_{ref} is the resistance of tungsten filament at reference temperature 20 ℃ (or $293.15\ K$), $\alpha = 6 \cdot 10^{-3}\ 1/K$ is the temperature coefficient of resistance of tungsten, T the temperature of the tungsten filament (in our case $2003.15\ K$), T_{ref} is the reference temperature that α is specified at for the tungsten (in our case $293.15\ K$).

From this formula we can find R_{ref}:

$$R_{ref} = \frac{R}{\left[1 + \alpha\left(T - T_{ref}\right)\right]} = \frac{4\ \Omega}{\left[1 + 6 \cdot 10^{-3}\ \frac{1}{K} \cdot (2003.15\ K - 293.15\ K)\right]} = 0.35\ \Omega.$$

Answer:

The resistance of the lamp at a room temperature of 20 ℃ is $R_{ref} = 0.35\ \Omega$.

6. A certain resistance thermometer at triple point of water has resistance of $152.0\ \Omega$. What is the temperature of the system in degrees Celsius when the resistance of the thermometer is $230.51\ \Omega$?

a) 414.2 ℃

b) 141.0 ℃

c) 253.2 ℃

d) 80.4 ℃

Solution:

We can find the temperature of the system from the same formula as in Problem 5:

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

here, $R = 230.51\ \Omega$ is the resistance of the thermometer at temperature T, $R_0 = 152.0\ \Omega$ is the resistance of the thermometer at triple point of water, $T_0 = 0.01$ ℃ is the triple point of water, $\alpha = 6.42 \cdot 10^{-3}\ 1/℃$ (unfortunately, we don't know from the condition of the question, the temperature coefficient of resistivity of the thermometer resistance, so let suppose that the thermometer resistance is made from a tungsten, for example). Then, we can get:

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

$$R = R_0 + \alpha R_0 T - \alpha R_0 T_0,$$

$$R - R_0 + \alpha R_0 T_0 = \alpha R_0 T,$$

$$T = \frac{R - R_0(1 - \alpha T_0)}{\alpha R_0} = \frac{230.51\ \Omega - 152.0\ \Omega \cdot \left(1 - 6.42 \cdot 10^{-3}\,\frac{1}{^\circ\mathrm{C}} \cdot 0.01\ ^\circ\mathrm{C}\right)}{6.42 \cdot 10^{-3}\,\frac{1}{^\circ\mathrm{C}} \cdot 152.0\ \Omega} =$$

$$= 80.4^\circ\mathrm{C}.$$

Answer:

$T = 80.4^\circ\mathrm{C}.$