Q. 03 . A room AC runs for 5 a day at a voltage of 220 V. The wiring of the room consists of Cu of 1 mm radius and a length of 10 m. Power consumption per day is 10 commercial units. What fraction of it goes in the joule heating in wires? What would happen if the wiring is made of aluminium of the same dimensions?

$[\rho_{Cu} = 11.7 \times 10^{-8}\ \Omega m,\ \rho_{Al} = 2.7 \times 10^{-8}\ \Omega m]$

Solution:

Key concept: The energy dissipated per unit time is the power dissipated $P = \frac{\Delta W}{\Delta t}$ and,

The power across a resistor is $P = I^2R$

Power consumption in a day, *i.e.*, in 5 = 10 units

Or power consumption per hour = 2 units

Or power consumption = 2 units = 2 kW = 2000 J/s

Also, we know that power consumption in resistor,

$P = V \times I$

$\Rightarrow$ 2000 W = 220 V $\times$ I or $I \approx 9$ A

Now, the resistance of wire with cross-sectional area A is given by $R = \rho\frac{l}{A}$

Power consumption in first current carrying wire is given by

$$P = I^2 R$$

$$\rho\frac{l}{A}I^2 = 1.7\times10^{-8}\times\frac{10}{\pi\times10^{-6}}\times 81\ \text{J/s} \approx 4\ \text{J/s}$$

The fractional loss due to the joule heating in first wire $= \frac{4}{2000}\times 100 = 0.2\%$

Power loss in Al wire $= 4\frac{\rho_{Al}}{\rho_{Cu}} = 1.6\times 4 = 6.4\ \text{J/s}$

The fractional loss due to the joule heating in second wire $= \frac{6.4}{2000}\times 100$

$= 0.32\%$