Answer on Question #53696, Physics Mechanics Kinematics Dynamics

Define coefficient of thermal conductivity of a material. A cubical thermocole box of side 20 cm and wall thickness 4 cm is full of ice. If outside temperature is 40 °C, estimate the amount of ice melted in five hours (K for thermocol is 0.01 J s–1 °C–1 and latent heat of fusion of ice is 335 J g–1)

Solution

The quantity of heat flowing into the ice through all six faces of the box is given by Eq.(1)

$$Q = \frac{KA(\theta_1 - \theta_2)t}{x} \qquad (1)$$

If m be the mass of the ice melted due to this heat and L, the heat of fusion of water, then $Q = mL$.

Thus,

$$mL = \frac{KA(\theta_1 - \theta_2)}{x} \qquad (2)$$

Here, the area of each face of cubical box $(side)^2 = 20 \times 20 = 400cm^2 = 0.04m^2$

The total area of all six faces of the cubical box, $A = 6 \cdot 0.04 = 0.24m^2$

Thickness of each face, $x = 0.04m$

The time for which heat flows, $t = 5hr = 5 \cdot 60 \cdot 60 = 18000\sec$

The heat of fusion of water $L = 335J / gm$

Thermal conductivity of thermocole, $K = 0.01 J/(\sec \cdot m \cdot {}^0C)$

The temperature difference, $\theta_1 - \theta_2 = 40 - 0 = 40^0 C$

Mass of the ice melted,

$$m = \frac{KA(\theta_1 - \theta_2)t}{xL} = \frac{0.01 \cdot 0.24 \cdot 40 \cdot 18000}{0.05 \cdot 335} = 103.16 gm = 0.103 kg$$

Answer: $m = \frac{KA(\theta_1 - \theta_2)t}{xL} = 0.103 kg$