Answer on Question #51621, Physics, Other

A closed cubical box (60cm on edge and 3cm on thickness) contains ice at 0 ^oC. When the outside temperature is 30 ^oC, it is found that 250 grams of ice melt each hour. What is thermal conductivity of the walls of the box? (heat of fusion of ice L=333x10^3 J/kg

Solution:

We assume that all of the heat conducted into the box goes into melting the ice, and none into raising the temperature inside the box. The area through which the heat is conducted is the total area of the six surfaces of the box, and the length of the conducting material is the thickness of the wall.

The total cross sectional area is given as

$$A = 6 * 0.6 * 0.6 = 2.16\ \mathrm{m}^2$$

The heat conducted is the heat released by the melting ice,

$$Q = m_{ice}\, L_{fusion} = 0.250 * 333 * 10^3 = 83250\ \mathrm{J}$$

The power conducted is

$$\frac{Q}{t} = \frac{k \cdot A \cdot \Delta T}{x}$$

where k is thermal conductivity, A is the surface area, ΔT is the difference in temperature, t is the time and x is the thickness.

Hence,

$$k = \frac{Qx}{A\Delta Tt} = \frac{83250 * 0.03}{2.16 * 30 * 3600} = 0.0107\ \frac{\mathrm{W}}{\mathrm{m°C}}$$

Answer: $k = 0.0107\ \frac{\mathrm{W}}{\mathrm{m°C}}$