Question#18832

The temperature of an electronic oven is 167.3 C. The temperature at the outer surface of the oven in the kitchen is 48.8 C. The oven (surface area = 1.7 m2) is insulated with material that has a thickness of 0.02 m and a thermal conductivity of 0.04 J/(s m C). How much energy in Joules will be used to operate the oven over 3 hours?

Solution:

Let:

$t_0 = 48.8$ ℃

$t_1 = 167.3$ ℃

$S = 1.7\ m^2$

$d = 0.02\ m$

$k = 0.04\ J/sm$℃

$T = 3\ hours = 10800\ sec$

$Q-?$

$Q = qT$, were q - the heat flux, T - time

According to the Fourier's law (the law of heat conduction):

$$\boldsymbol{q = k\frac{S\Delta t}{d}}$$

$$\boldsymbol{\Delta t = t_1 - t_0}$$

$$\boldsymbol{q = k\frac{S(t_1 - t_0)}{d}}$$

$$\boldsymbol{Q = kT\frac{S(t_1 - t_0)}{d}}$$

$$\boldsymbol{Q = 0.04 * 10800 * \frac{1.7(167.3-48.8)}{0.02} = 2559600\ J}$$

Answer: 259600 J (256.6 KJ)