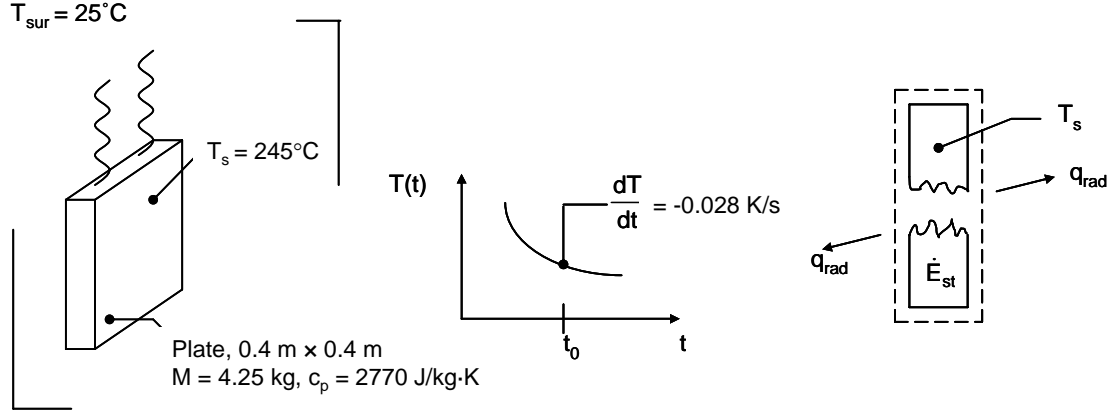# PROBLEM 1.32

KNOWN: Hot plate suspended in vacuum and surroundings temperature. Mass, specific heat, area and time rate of change of plate temperature.

FIND: (a) The emissivity of the plate, and (b) The rate at which radiation is emitted from the plate.

SCHEMATIC:

ASSUMPTIONS: (1) Plate is isothermal and at uniform temperature, (2) Large surroundings, (3) Negligible heat loss through suspension wires.

ANALYSIS: For a control volume about the plate, the conservation of energy requirement is

$$\dot{E}_{in} - \dot{E}_{out} = \dot{E}_{st} \tag{1}$$

where $\dot{E}_{st} = Mc_p \dfrac{dT}{dt}$ (2)

and for large surroundings $\dot{E}_{in} - \dot{E}_{out} = A\varepsilon\sigma(T_{sur}^4 - T_s^4)$ (3)

Combining Eqns. (1) through (3) yields

$$\varepsilon = \frac{Mc_p}{A\sigma} \frac{\dfrac{dT}{dt}}{(T_{sur}^4 - T_s^4)}$$

Noting that $T_{sur} = 25°C + 273\ K = 298\ K$ and $T_s = 245°C + 273\ K = 518\ K$, we find

$$\varepsilon = \frac{4.25\ kg \ \times \ 2770\dfrac{J}{kg \cdot K} \ \times \ (\text{-}0.028\dfrac{K}{s})}{2 \times 0.4\ m \times 0.4\ m \times 5.67 \times 10^{\text{-}8}\dfrac{W}{m^2 \cdot K^4}(298^4 \text{-} 518^4)\ K^4} = 0.28 \qquad <$$

The rate at which radiation is emitted from the plate is

$$q_{rad,e} = \varepsilon A\sigma T_s^4 = 0.28 \times 2 \times 0.4\ m \times 0.4\ m \times 5.67 \times 10^{\text{-}8}\frac{W}{m^2 \cdot K^4} \times (518\ K)^4 = 370\ W \qquad <$$

COMMENTS: Note the importance of using kelvins when working with radiation heat transfer.