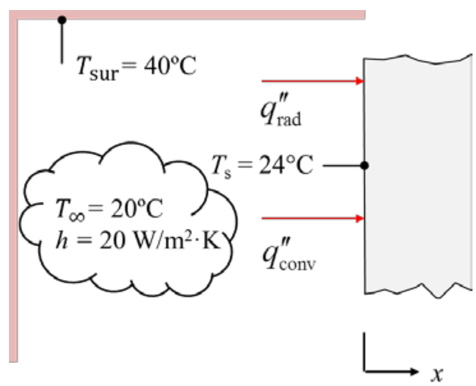
PROBLEM 04

KNOWN: Ambient, surface, and surroundings temperatures, convection heat transfer coefficient, and absorptivity of a plane wall.

FIND: Convective and radiative heat fluxes to the wall at $x = 0$.

SCHEMATIC:



ASSUMPTIONS: (1) Exposed wall surface is gray ($\alpha = \varepsilon$), (2) large surroundings.

ANALYSIS: The convection heat flux to the wall is described by Newton's law of cooling,

$$q''_{\text{conv}} = h(T_\infty - T_1) = 20\text{W/m}^2 \cdot \text{K} \times (20°\text{C} - 24°\text{C}) = -80 \text{ W/m}^2 \qquad <$$

The negative sign indicates that the convection heat transfer is from the wall to the ambient.

The net radiation heat flux to the wall is determined from

$$q''_{\text{rad}} = \varepsilon\sigma\left(T_{\text{sur}}^4 - T_s^4\right) = 0.78 \times 5.67 \times 10^{-8}\,\text{W/m}^2 \cdot \text{K}^4 \times \left((40+273)^4 - (24+273)^4\right)\text{K}^4 = 80\text{W/m}^2 <$$

The net radiation heat flux is to the wall from the surroundings.

Since the radiation and convection heat fluxes are equal and opposite, the net heat flux to the wall is zero.

COMMENTS: (1) If the wall is constructed of a thermally-insulating material, its thermal conductivity will be small, and the conduction heat flux inside the wall will also be small. This situation leads to the requirement that the *sum* of the convective and net radiative fluxes at $x = 0$ be small, such as the case here. (2) Note the importance of converting the temperatures to kelvins when solving for the radiation heat flux.