36.31 A heat sink is designed to remove $25W$ from a computer CPU. The ambient air inside the machine is $90°F$ and the surface temperature of the heat sink is not to exceed $140°F$. The combined heat transfer coefficient, including both convection and radiation, is $3\frac{Btu}{hr \cdot ft^{2} \cdot °F}$. What is the minimum required surface area for the heat sink?

A. $7in^2$

B. $24in^2$

C. $82in^2$

D. $148in^2$

The overall heat transfer is given by the equation below, where the overall coefficient of heat transfer, U, *includes* both convection and radiation.

$$\dot{Q} = UA\Delta T$$

Solve for the area. Substitute the amount of heat to be removed, the overall heat transfer coefficient, and the temperatures to determine the surface area. Since the area calculation is based on the *largest* allowable temperature differential, the value obtained represents the *minimum* area required to ensure the upper temperature limit is not exceeded. Convert to square inches.

$$A = \frac{\dot{Q}}{U\Delta T} = \frac{(25W)\left(3.412\frac{Btu}{hr \cdot W}\right)}{\left(3\frac{Btu}{hr \cdot ft^{2} \cdot °F}\right)(140°F - 90°F)} = 0.57ft^2$$

$$A = 0.57ft^2\left(\frac{12in}{1ft}\right)^2 = 82in^2$$

Answer C