Use one of the formulas under Properties for Two-Phase (Vapor-Liquid) Systems to solve for s_2.

$$s_2 = s_f + \chi_2 s_{fg} = 0.4344\frac{Btu}{lb_m \cdot {}^\circ R} + \left(\frac{1}{3}\right)\left(1.2035\frac{Btu}{lb_m \cdot {}^\circ R}\right) = 0.8356\frac{Btu}{lb_m \cdot {}^\circ R}$$

Calculate the change in entropy, Δs.

$$\Delta s = s_2 - s_1 = 0.8356\frac{Btu}{lb_m \cdot {}^\circ R} - 0.4344\frac{Btu}{lb_m \cdot {}^\circ R} = 0.401\frac{Btu}{lb_m \cdot {}^\circ R}$$

Alternatively, a faster solution would be to recognize that the change in entropy will be one third of the entropy of vaporiation, s_{fg}, since one third of the total mass is changing phase.

$$\Delta s = \left(\frac{1}{3}\right) s_{fg} = \left(\frac{1}{3}\right)\left(1.2035\frac{Btu}{lb_m \cdot {}^\circ R}\right) = 0.401\frac{Btu}{lb_m \cdot {}^\circ R}$$

Answer A

46.30 A counterflow heat exchanger is used to cool a fluid from $180^\circ F$ to $140^\circ F$. The cooling medium temperature increases from $60^\circ F$ to $120^\circ F$. What is the log mean temperature difference?

A. $56^\circ F$

B. $60^\circ F$

C. $64^\circ F$

D. $70^\circ F$

Sketch the heat exchanger or draw a Temperature vs. Length diagram to depict the direction of flow, and label all temperatures. The fluids flow in opposite directions because it is a *counterflow* heat exchanger.

$$180^\circ F \longrightarrow 140^\circ F$$

$$120^\circ F \longleftarrow 60^\circ F$$

Calculate the temperature differential on each physical side of the exchanger, arbitrarily labeling the sides A & B.

$$\Delta T_A = 180^\circ F - 120^\circ F = 60^\circ F$$

$$\Delta T_B = 140^\circ F - 60^\circ F = 80^\circ F$$

Calculate the Log Mean Temperature Difference, ΔT_{lm}. The formula below is consistent with the formula shown in the reference handbook, but may be easier to correctly apply once the temperature differentials are properly defined. Note that interchanging ΔT_A and ΔT_B leads to the same correct result!

$$\Delta T_{lm} = \frac{\Delta T_A - \Delta T_B}{ln\left(\frac{\Delta T_A}{\Delta T_B}\right)}$$

$$\Delta T_{lm} = \frac{60^\circ F - 80^\circ F}{ln\left(\frac{60^\circ F}{80^\circ F}\right)} = 69.5^\circ F$$

Answer D

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

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

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

Answer C