$$T = 68°F$$

$$p_{ws} = 0.34psia$$

Solve for the vapor pressure.

$$p_w = \phi p_{ws} = (0.45)\,(0.34psia) = 0.153psia$$

Convert from $psia$ to $in\,Hg$. Refer to Measurement Relationships for necessary converstions.

$$p_w = (0.153psia)\left(\frac{2.036in\,Hg}{1psi}\right) = 0.31in\,Hg$$

Answer B

46.29 Saturted liquid water at $50psig$ is boiled in a sealed vessel at constant pressure until one third of the water by mass has changed to a vapor phase. What is the change in entropy of the mixture during this process?

A. $0.40\frac{Btu}{lb_m \cdot °R}$

B. $0.42\frac{Btu}{lb_m \cdot °R}$

C. $0.80\frac{Btu}{lb_m \cdot °R}$

D. $0.83\frac{Btu}{lb_m \cdot °R}$

Start by finding the entropy for the initial condition, State 1. Since the water is a saturated liquid, the entropy at State 1 corresponds to s_f for the pressure given. Use the table Properties of Saturated Water and Steam (Pressure) to obtain the entropy, s_1.

$$P_1 = 50psig \approx 65psia$$

$$s_1 = s_f = 0.4344\frac{Btu}{lb_m \cdot °R}$$

Also obtain the entropy of vaporation, s_{fg}, from the same line in the steam table for use in the following step.

$$s_{fg} = 1.2035\frac{Btu}{lb_m \cdot °R}$$

Since the water is boiled at constant pressure until a third of the mass has changed to vapor, the quality at State 2, χ_2, is $\frac{1}{3}$. This is the definition of quality.

$$\chi_2 = \frac{m_{vapor}}{m_{vapor} + m_{liquid}} = \frac{m_{vapor}}{m_{total}} = \frac{1}{3}$$

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!