$$COP_R = \frac{Q_L}{W} \rightarrow W = \frac{Q_L}{COP} = \frac{3000\frac{Btu}{hr}}{4.4} = 682\frac{Btu}{hr}\left(\frac{1W}{3.412\frac{Btu}{hr}}\right) = 200W$$

Answer B

39.18 A refrigeration cycle using R-123 operates between $25psia$ and $75psia$. Refrigerant enters the compressor with $20°F$ of superheat and leaves the condenser as a saturated liquid. What is the coefficient of performance?

A. 5.8

B. 6.7

C. 7.3

D. 10.5

In the reference handbook lookup Pressure Versus Enthalpy Curves for Refrigerant 123 and work around the cycle finding the enthalpy for each state point.

State 1, entering compressor. By definition this is the low pressure side of the cycle. To find the temperature, move horizontally from the rightmost edge of the saturation curve into the superheated region to account for the superheat. Read the enthalpy vertically up or down. Use the Refrigerant 123 table for greater precision.

$$P_1 = 25psia$$

$$T_1 = T_{sat} + 20°F = 110°F + 20°F = 130°F$$

$$h_1 = 108.8\frac{Btu}{lb}$$

State 2, leaving compressor. The compression $1 \rightarrow 2$ is assumed to be isentropic if no compressor efficiency is mentioned. Move along a line of constant entropy and increasing pressure from state 1 to state 2. Read the enthalpy.

$$P_2 = 75psia$$

$$s_2 = s_1$$

$$h_2 \approx 117\frac{Btu}{lb}$$

State 3, leaving condenser. The condensing $2 \to 3$ is constant pressure. Move horizontally to the left to the edge of the saturation curve, where the refrigerant is a saturated liquid. Always assume saturated liquid condition for state 3 (quality is zero) if there is no mention of subcooling. Read the enthalpy.

$$P_3 = 75psia$$

$$\chi = 0$$

$$h_3 = 53.6\frac{Btu}{lb}$$

State 4, entering compressor. The expansion $3 \to 4$ is assumed to be isenthalpic. Follow a vertical line down to the low pressure side. Note that state 4 will be a saturated mixture.

$$P_4 = 25psia$$

$$h_4 = h_3 = 53.6\frac{Btu}{lb}$$

In the reference handbook lookup coefficient of performance for a refrigerator and use the formula:

$$COP_R = \frac{Q_L}{W}$$

where Q_L is the heat absorbed by the evaporator from state $4 \to 1$. Therefore, Q_L can be expressed as the product of $\dot{m}$, the mass flow rate of refrigerant around the cycle, and the difference in enthalpy across the evaporator, $h_1 - h_4$. Similarly, the work done by the compressor, W, can be expressed as the product of $\dot{m}$, the mass flow rate of refrigerant around the cycle, and the difference in enthalpy across the compressor, $h_2 - h_1$. When these substitutions are made, the mass flow rate cancels out of the numerator and denominator, simplifying the COP as such:

$$COP_R = \frac{Q_L}{W} = \frac{(\dot{m})(h_1 - h_4)}{(\dot{m})(h_2 - h_1)} = \frac{(h_1 - h_4)}{(h_2 - h_1)} = \frac{\left(108.8\frac{Btu}{lb} - 53.6\frac{Btu}{lb}\right)}{\left(117\frac{Btu}{lb} - 108.8\frac{Btu}{lb}\right)} = 6.7$$

Answer B