39.16 A refrigerator draws $800W$ of power and absorbs $4000\frac{Btu}{hr}$ from the internal volume. What is the coefficient of performance?

A. 0.7

B. 1.5

C. 1.7

D. 5.0

Look up Coefficient of Performance for a Refrigerator in the reference handbook and use the formula:

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

where Q_L is the refrigeration effect i.e. the heat removed from the cold space and W is the work done by the compressor to drive the refrigeration process. Note that the units must cancel completely as the COP should be unitless. Substitute and solve.

$$COP_R = \frac{Q_L}{W} = \frac{4000\frac{Btu}{hr}}{800W\left(3.412\frac{Btu}{hr\cdot W}\right)} = 1.5$$

Answer B

39.17 The cold and hot reservoirs of a reversed Carnot refrigeration cycle are $-20°F$ and $80°F$, respectively. $3000\frac{Btu}{hr}$ are absorbed from the cold reservoir. What is the work input?

A. $160W$

B. $200W$

C. $700W$

D. $1100W$

Find the coefficient of performance for a Carnot Refrigerator in the reference handbook as having the formula:

$$COP_{R,carnot} = \frac{T_L}{T_H - T_L}$$

where T_L and T_H are the low and high reservoir temperatures, respectively, in absolute degrees i.e. Rankine. Therefore the COP can be determined as such:

$$COP_{R,carnot} = \frac{T_L}{T_H - T_L} = \frac{-20°F + 460}{[(80°F + 460) - (-20°F + 460)]} = \frac{440°R}{100°R} = 4.4$$

Having been given the rate of heat removal from the cold reservoir and calculated the COP for the cycle, the compressor work to drive the refrigeration process can be calculated:

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

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 $1 \to 2$ 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.

$$P_2 = 75psia$$

$$s_2 = s_1$$

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