Solve for the mass flow rate of air. Convert units to $\frac{lb}{min}$:

$$\dot{Q}_{air} = \dot{m}_{air}\Delta h \rightarrow \dot{m}_{air} = \frac{\dot{Q}_{air}}{h_2 - h_1} = \frac{1,200,000\frac{Btu}{hr}}{\left(67.76\frac{Btu}{lb} - 40.03\frac{Btu}{lb}\right)} = 43,274\frac{lb}{hr}$$

$$\dot{m}_{air} = 43,274\frac{lb}{hr}\left(\frac{1hr}{60min}\right) = 721.2\frac{lb}{min}$$

Find the mass flow rate of water being added to the air stream and convert to gpm. Note, the formula used is derived from the definition of the humidity ratio and is best memorized rather than looked up or derived:

$$\dot{m}_w = \dot{m}_a\left(\omega_2 - \omega_1\right)$$

$$\dot{m}_w = \left(721.2\frac{lb}{min}\right)\left(.03866\frac{lb_w}{lb_{da}} - .01719\frac{lb_w}{lb_{da}}\right) = 15.5\frac{lb}{min}$$

$$\dot{m}_w = 15.5\frac{lb}{min}\left(\frac{1ft^3}{62.4lb}\right)\left(\frac{7.48gal}{1ft^3}\right) = 1.86gpm$$

Answer D

44.12 R-410a is used in a chiller with a suction pressure of $60psia$ and a discharge pressure of $185psia$. The refrigeration cycle operates with $20°F$ of sub cooling and $20°F$ of superheating. The load on the chiller is $200tons$. What is the mass flow rate of refrigerant?

A. $420\frac{lb}{min}$

B. $440\frac{lb}{min}$

C. $460\frac{lb}{min}$

D. $480\frac{lb}{min}$

Look up Pressure Versus Enthalpy Curves for Refrigerant 410A in the Reference Handbook and draw the refrigeration cycle directly on the screen. If drawing on the screen is unworkable, sketch on scrap paper and mark key values obtained from the chart on the axes. Note the vertical axis is nonlinear so take special care to identify the low and high pressure conditions for the evaporator and condenser.

The load on the chiller is the refrigeration effect, $\dot{Q}_{in}$. Express the refrigeration effect as the mass flow rate times the change in enthalpy across the evaporator, typically represented as $h_1 - h_4$.

$$\dot{Q}_{in} = \dot{m}\left(h_1 - h_4\right)$$

State 1, leaving the evaporator and entering the condenser, must be selected to the right of the saturation curve in the superheated region to account for 20˚F of superheat.

State 3, leaving the condenser and entering the expansion valve, must be selected to the left of the saturation curve in the subcooled region to account for 20°F of subcooling. Since the expansion process $3 \rightarrow 4$ is isenthalpic, assume $h_4 = h_3$.

Solve for mass flow rate, substitute enthalpy values, and convert units where necessary:

$$\dot{Q}_{in} = \dot{m}\left(h_1 - h_4\right) = \dot{m}\left(h_1 - h_3\right)$$

$$\dot{m} = \frac{\dot{Q}_{in}}{\left(h_1 - h_3\right)} = \frac{\left(200 tons\right)\left(12,000 \frac{Btu}{hr \cdot ton}\right)}{\left(122 \frac{Btu}{lb} - 28 \frac{Btu}{lb}\right)} = 25,532 \frac{lb}{hr}$$

$$\dot{m} = 25,532 \frac{lb}{hr}\left(\frac{1 hr}{60 min}\right) = 425 \frac{lb}{min}$$

Answer A

44.13 R-134a is used in a chiller with an evaporator pressure of $30 psia$ and a condenser pressure of $150 psia$. There is $20°F$ of superheat. What is the coefficient of performance?

A. 3

B. 4

C. 5

D. 6

Look Up Pressure Versus Enthalpy Curves for Refrigerant 134a in the Reference Handbook and draw the refrigeration cycle directly on the screen. If drawing on the screen is unworkable, sketch on scrap paper and mark key values obtained from the chart on the axes. Assume State 3, leaving the condenser and entering the expansion valve, is a saturated liquid since there is no mention of subcooling. Locate State 1 to the right of the saturation curve in the superheated region to account for 20°F of superheat. The enthalpy at State 4 is equal to the enthalpy at State 3 assuming isenthalpic expansion. Note the vertical axis is nonlinear so take special care to identify the low and high pressure conditions for the evaporator and condenser.

Calculate the Coefficient of Performance (COP) for the refrigeration cycle:

$$COP_R = \frac{\dot{Q}_{in}}{\dot{W}_{in}} = \frac{\dot{m}\left(h_1 - h_4\right)}{\dot{m}\left(h_2 - h_1\right)} = \frac{\left(h_1 - h_3\right)}{\left(h_2 - h_1\right)} = \frac{\left(109 \frac{Btu}{lb} - 47 \frac{Btu}{lb}\right)}{\left(122 \frac{Btu}{lb} - 109 \frac{Btu}{lb}\right)} = 4.8$$

Answer C