

$$\phi_r = 50\%$$

$$h_r = 29.6 \frac{Btu}{lb}$$

Rearrange the total heat gain formula, substitute, and solve for the cfm. Use the **measurement relationship**:  $1 \text{ ton} = 12,000 \frac{Btu}{hr}$ . Provided the heat gain is in  $\frac{Btu}{hr}$  and the enthalpy is in  $\frac{Btu}{lb}$ , the *cfm* units will work out automatically using this rule of thumb, hence units need not be shown.

$$Q_t = 3.74cfm\Delta h \rightarrow cfm = \frac{Q_t}{3.74\Delta h}$$

$$cfm = \frac{Q_t}{3.74\Delta h} = \frac{Q_t}{3.74(h_r - h_s)} = \frac{12,000}{3.74(29.6 - 23.2)} = 501cfm$$

**Answer B**

**41.9 How much condensate is produced by a 10,000cfm air handling unit supplying 60°F dry bulb, 58°F wet bulb air? The return air conditions are 76°F and 60% relative humidity.**

- A. 0.002gpm
- B. 0.11gpm
- C. 0.16gpm
- D. 1.3gpm

The rate at which condensate is produced is the mass flow rate of water, which depends on the mass flow rate of air and the difference in the humidity ratio between the supply and return air streams. The governing formula can be found in the Reference Handbook by searching **Moist-Air Cooling and Dehumidification**:

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

Let state 1 refer to the return condition which is expected to have greater moisture content, and state 2 shall refer to the supply condition after moisture removal by the coil. This ensures  $\Delta\omega > 0$ . Otherwise the process would be *humidification* rather than *dehumidification*.

Both states are fully defined. Use the **psychrometric chart** to look up the humidity ratios for each state. Also look up the specific volume for the return condition, state 1, entering the coil.

$$T_{1,db} = 76^\circ F$$

$$\phi_1 = 60\%$$

$$\omega_1 = .0116 \frac{lb_w}{lb_{da}}$$

$$v_1 = 13.8 \frac{ft^3}{lb}$$

$$T_{2,db} = 60^\circ F$$

$$T_{2,wb} = 58^\circ F$$

$$\omega_2 = .0098 \frac{lb_w}{lb_{da}}$$

The mass flow rate of air can be expressed as the volume flow rate divided by the specific volume:

$$\dot{m}_a = \frac{\bar{Q}}{v} = \frac{10,000 \frac{ft^3}{min}}{13.8 \frac{ft^3}{lb_{da}}}$$

Substitute this expression into the first formula for the mass flow rate of air entering the coil, along with the humidity ratios, and solve for the mass flow rate of water removed. Convert units to *gpm* by using the density of water and the **measurement relationship** between gallons and cubic feet. Alternatively, search **Commonly Used Equivalents** to convert directly from *lb* to *gal* in one step using  $8.34 \frac{lb_m}{gal}$  for water.

$$\dot{m}_w = \dot{m}_a (\omega_1 - \omega_2) = \left( \frac{10,000 \frac{ft^3}{min}}{13.8 \frac{ft^3}{lb_{da}}} \right) \left( 0.0116 \frac{lb_w}{lb_{da}} - 0.0098 \frac{lb_w}{lb_{da}} \right) = 1.3 \frac{lb_w}{min}$$

$$\dot{m}_w = 1.3 \frac{lb}{min} \left( \frac{1 ft^3}{62.4 lb} \right) \left( \frac{7.48 gal}{1 ft^3} \right) = 0.16 gpm$$

**Answer C**

**41.10 What is the specific heat capacity of atmospheric air at  $90^\circ F$  dry bulb and  $70^\circ F$  wet bulb?**

- A.  $0.238 \frac{Btu}{lb_m \cdot ^\circ F}$
- B.  $0.240 \frac{Btu}{lb_m \cdot ^\circ F}$
- C.  $0.242 \frac{Btu}{lb_m \cdot ^\circ F}$
- D.  $0.245 \frac{Btu}{lb_m \cdot ^\circ F}$

Typically the specific heat capacity of air at standard temperature and pressure may be taken as the standard value of  $c_{p,air} = 0.240 \frac{Btu}{lb_m \cdot ^\circ F}$ , as given in the Reference Handbook table **Thermal and Physical Properties of Ideal Gases**. However, there is an embedded assumption that the air is dry air. But in fact, the mixture contains both dry air (nitrogen and oxygen) and water vapor. Using the same table, or by searching **specific heat of water vapor**, note that  $c_{p,steam} = 0.445 \frac{Btu}{lb_m \cdot ^\circ F}$ . By treating moist air as a mixture of dry air and water vapor, recognize the specific heat capacity will depend on the mass fraction of each substance. Option A should be eliminated because the specific