14-105 Two airstreams are mixed steadily. The specific humidity, the relative humidity, the dry-bulb temperature, and the volume flow rate of the mixture are to be determined.

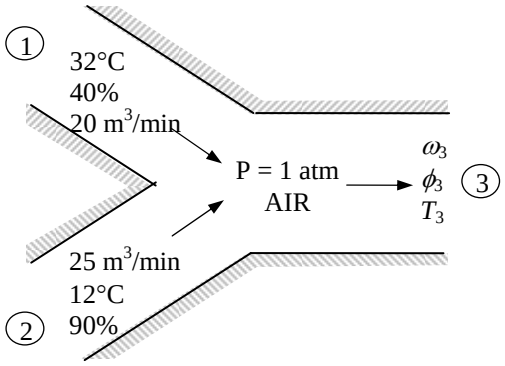
Assumptions **1** Steady operating conditions exist **2** Dry air and water vapor are ideal gases. **3** The kinetic and potential energy changes are negligible. **4** The mixing section is adiabatic.

Properties Properties of each inlet stream are determined from the psychrometric chart (Fig. A-31) to be

$$h_1 = 62.7 \text{ kJ/kg dry air}$$
$$\omega_1 = 0.0119 \text{ kg H}_2\text{O/kg dry air}$$
$$\nu_1 = 0.882 \text{ m}^3\text{/kg dry air}$$

and

$$h_2 = 31.9 \text{ kJ/kg dry air}$$
$$\omega_2 = 0.0079 \text{ kg H}_2\text{O/kg dry air}$$
$$\nu_2 = 0.819 \text{ m}^3\text{/kg dry air}$$



Analysis The mass flow rate of dry air in each stream is

$$\dot{m}_{a1} = \frac{\dot{V}_1}{\nu_1} = \frac{20 \text{ m}^3/\text{min}}{0.882 \text{ m}^3/\text{kg dry air}} = 22.7 \text{ kg/min}$$
$$\dot{m}_{a2} = \frac{\dot{V}_2}{\nu_2} = \frac{25 \text{ m}^3/\text{min}}{0.819 \text{ m}^3/\text{kg dry air}} = 30.5 \text{ kg/min}$$

From the conservation of mass,

$$\dot{m}_{a3} = \dot{m}_{a1} + \dot{m}_{a2} = (22.7 + 30.5) \text{ kg/min} = 53.2 \text{ kg/min}$$

The specific humidity and the enthalpy of the mixture can be determined from Eqs. 14-24, which are obtained by combining the conservation of mass and energy equations for the adiabatic mixing of two streams:

$$\frac{\dot{m}_{a1}}{\dot{m}_{a2}} = \frac{\omega_2 - \omega_3}{\omega_3 - \omega_1} = \frac{h_2 - h_3}{h_3 - h_1}$$
$$\frac{22.7}{30.5} = \frac{0.0079 - \omega_3}{\omega_3 - 0.0119} = \frac{31.9 - h_3}{h_3 - 62.7}$$

which yields,

$$\omega_3 = \mathbf{0.0096 \text{ kg H}_2\text{O/kg dry air}}$$
$$h_3 = 45.0 \text{ kJ/kg dry air}$$

These two properties fix the state of the mixture. Other properties of the mixture are determined from the psychrometric chart:

$$T_3 = \mathbf{20.6°C}$$
$$\phi_3 = \mathbf{63.4\%}$$
$$\nu_3 = 0.845 \text{ m}^3\text{/kg dry air}$$

Finally, the volume flow rate of the mixture is determined from

$$\dot{V}_3 = \dot{m}_{a3}\nu_3 = (53.2 \text{ kg/min})(0.845 \text{ m}^3/\text{kg}) = \mathbf{45.0 \text{ m}^3\text{/min}}$$