14-63 The infiltration rate of a building is estimated to be 0.9 ACH. The sensible, latent, and total infiltration heat loads of the building at sea level are to be determined.

Assumptions **1** Steady operating conditions exist. **2** The air infiltrates at the outdoor conditions, and exfiltrates at the indoor conditions. **3** Excess moisture condenses at room temperature of 24°C. **4** The effect of water vapor on air density is negligible.

Properties The gas constant and the specific heat of air are $R = 0.287$ kPa.m^3/kg.K and $c_p = 1.005$ kJ/kg·°C (Table A-2). The heat of vaporization of water at 24°C is $h_{fg} = h_{fg\,@\,24°C} = 2444.1$ kJ/kg (Table A-4). The properties of the ambient and room air are determined from the psychrometric chart (Fig. A-31) to be

$$\left.\begin{array}{l} T_{ambient} = 38°C \\ \phi_{ambient} = 35\% \end{array}\right\} w_{ambient} = 0.01458 \text{ kg/kg dryair}$$

$$\left.\begin{array}{l} T_{room} = 24°C \\ \phi_{room} = 55\% \end{array}\right\} w_{room} = 0.01024 \text{ kg/kg dryair}$$

Analysis Noting that the infiltration of ambient air will cause the air in the cold storage room to be changed 0.9 times every hour, the air will enter the room at a mass flow rate of

$$\rho_{ambient} = \frac{P_0}{RT_0} = \frac{101.325 \text{ kPa}}{(0.287 \text{ kPa.m}^3/\text{kg.K})(38 + 273 \text{ K})} = 1.135 \text{ kg/m}^3$$

$$\dot{m}_{air} = \rho_{ambient} V_{room} \text{ACH} = (1.135 \text{ kg/m}^3)(20 \times 13 \times 3 \text{ m}^3)(0.9 \text{ h}^{-1}) = 797.0 \text{ kg/h} = 0.2214 \text{ kg/s}$$

Then the sensible, latent, and total infiltration heat loads of the room are determined to be

$$\dot{Q}_{infiltration,\,sensible} = \dot{m}_{air} c_p (T_{ambient} - T_{room}) = (0.2214 \text{ kg/s})(1.005 \text{ kJ/kg.°C})(38 - 24)°C = \textbf{3.11 kW}$$

$$\dot{Q}_{infiltration,\,latent} = \dot{m}_{air} (w_{ambient} - w_{room}) h_{fg} = (0.2214 \text{ kg/s})(0.01458 - 0.01024)(2444.1 \text{ kJ/kg}) = \textbf{2.35 kW}$$

$$\dot{Q}_{infiltration,\,total} = \dot{Q}_{infiltration,\,sensible} + \dot{Q}_{infiltration,\,latent} = 3.11 + 2.35 = \textbf{5.46 kW}$$

Discussion The specific volume of the dry air at the ambient conditions could also be determined from the psychrometric chart at ambient conditions.