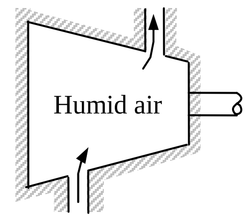
14-20 Humid air is compressed in an isentropic compressor. The relative humidity of the air at the compressor outlet is to be determined.

Assumptions The air and the water vapor are ideal gases.

Properties The specific heat ratio of air at room temperature is k = 1.4 (Table A-2a). The saturation properties of water are to be obtained from water tables.

Analysis At the inlet,



$$P_{v,1} = \phi_1 P_{g,1} = \phi_1 P_{\text{sat @ 20°C}} = (0.90)(2.3392\text{ kPa}) = 2.105\text{ kPa}$$

$$\omega_2 = \omega_1 = \frac{0.622 P_{v,1}}{P - P_{v,1}} = \frac{(0.622)(2.105\text{ kPa})}{(100 - 2.105)\text{ kPa}} = 0.0134\text{ kg H}_2\text{O/kg dry air}$$

Since the mole fraction of the water vapor in this mixture is very small,

$$T_2 = T_1 \left(\frac{P_2}{P_1}\right)^{(k-1)/k} = (293\text{ K})\left(\frac{800\text{ kPa}}{100\text{ kPa}}\right)^{0.4/1.4} = 531\text{ K}$$

The saturation pressure at this temperature is

$$P_{g,2} = P_{\text{sat @ 258°C}} = 4542\text{ kPa} \quad \text{(from EES)}$$

The vapor pressure at the exit is

$$P_{v,2} = \frac{\omega_2 P_2}{\omega_2 + 0.622} = \frac{(0.0134)(800)}{0.0134 + 0.622} = 16.87\text{ kPa}$$

The relative humidity at the exit is then

$$\phi_2 = \frac{P_{v,2}}{P_{g,2}} = \frac{16.87}{4542} = \mathbf{0.0037} = \mathbf{0.37\%}$$