4-92 The specific volume of steam is to be determined using the ideal gas relation, the compressibility chart, and the steam tables. The errors involved in the first two approaches are also to be determined.

Properties The gas constant, the critical pressure, and the critical temperature of water are, from Table A-1,

$$R = 0.4615 \text{ kPa·m}^3\text{/kg·K}, \qquad T_{cr} = 647.1 \text{ K}, \qquad P_{cr} = 22.06 \text{ MPa}$$

Analysis (*a*) From the ideal gas equation of state,

$$v = \frac{RT}{P} = \frac{(0.4615 \text{ kPa} \cdot \text{m}^3\text{/kg} \cdot \text{K})(723 \text{ K})}{3500 \text{ kPa}} = \mathbf{0.09533 \text{ m}^3\text{/kg}} \quad \mathbf{(3.7\% \text{ error})}$$

(*b*) From the compressibility chart (Fig. A-15),

$$\left.\begin{aligned} P_R &= \frac{P}{P_{cr}} = \frac{3.5 \text{ MPa}}{22.06 \text{ MPa}} = 0.159 \\ T_R &= \frac{T}{T_{cr}} = \frac{723 \text{ K}}{647.1 \text{ K}} = 1.12 \end{aligned}\right\} Z = 0.961$$

H_2O
3.5 MPa
450°C

Thus,

$$v = Zv_{\text{ideal}} = (0.961)(0.09533 \text{ m}^3\text{/kg}) = \mathbf{0.09161 \text{ m}^3\text{/kg}} \quad \mathbf{(0.4\% \text{ error})}$$

(*c*) From the superheated steam table (Table A-6),

$$\left.\begin{aligned} P &= 3.5 \text{ MPa} \\ T &= 450°\text{C} \end{aligned}\right\} \quad v = \mathbf{0.09196 \text{ m}^3\text{/kg}}$$

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