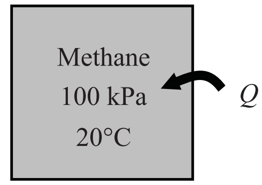
4-102 Methane is heated in a rigid container. The final pressure of the methane is to be determined using the ideal gas equation and the Benedict-Webb-Rubin equation of state.

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



$$P_2 = P_1 \frac{T_2}{T_1} = (100\text{ kPa})\frac{673\text{ K}}{293\text{ K}} = \mathbf{229.7\ kPa}$$

The specific molar volume of the methane is

$$\bar{v}_1 = \bar{v}_2 = \frac{R_u T_1}{P_1} = \frac{(8.314\text{ kPa}\cdot\text{m}^3/\text{kmol}\cdot\text{K})(293\text{ K})}{100\text{ kPa}} = 24.36\text{ m}^3/\text{kmol}$$

(*b*) The specific molar volume of the methane is

$$\bar{v}_1 = \bar{v}_2 = \frac{R_u T_1}{P_1} = \frac{(8.314\text{ kPa}\cdot\text{m}^3/\text{kmol}\cdot\text{K})(293\text{ K})}{100\text{ kPa}} = 24.36\text{ m}^3/\text{kmol}$$

Using the coefficients of Table 4-4 for methane and the given data, the Benedict-Webb-Rubin equation of state for state 2 gives

$$P_2 = \frac{R_u T_2}{\bar{v}_2} + \left(B_0 R_u T_2 - A_0 - \frac{C_0}{T_2^2}\right)\frac{1}{\bar{v}^2} + \frac{bR_u T_2 - a}{\bar{v}^3} + \frac{a\alpha}{\bar{v}^6} + \frac{c}{\bar{v}^3 T_2^2}\left(1 + \frac{\gamma}{\bar{v}^2}\right)\exp(-\gamma/\bar{v}^2)$$

$$= \frac{(8.314)(673)}{24.36} + \left(0.04260\times 8.314\times 673 - 187.91 - \frac{2.286\times 10^6}{673^2}\right)\frac{1}{24.36^2} + \frac{0.003380\times 8.314\times 673 - 5.00}{24.36^3}$$

$$+ \frac{5.00\times 1.244\times 10^{-4}}{24.36^6} + \frac{2.578\times 10^5}{24.36^3(673)^2}\left(1 + \frac{0.0060}{24.36^2}\right)\exp(-0.0060/24.36^2)$$

$$= \mathbf{229.8\,kPa}$$