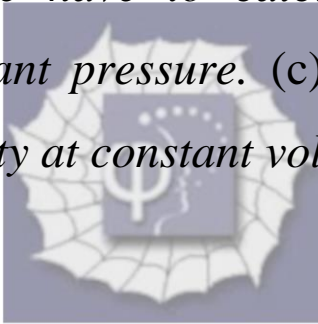


234.

Problem 25.41 (RHK)

Let 20.9 J of heat be added to a particular ideal gas. As a result, its volume changes from 63.0 to 113 cm³ while the pressure remains constant at 1.00 atm. (a) We have to calculate the change in the internal energy of the gas. (b) If the quantity of the gas present is 2.00×10^{-3} mol, we have to calculate the molar heat capacity at constant pressure. (c) We have to find the molar heat capacity at constant volume.



Solution:

(a)

The initial volume of the gas is

$$V_i = 63.0 \times 10^{-6} \text{ m}^3.$$

The final volume of the gas is

$$V_f = 113 \times 10^{-6} \text{ m}^3.$$

The work done on the gas at constant pressure

$$p = 1.00 \text{ atm} = 1.01 \times 10^5 \text{ Pa} \text{ will be}$$

$$W = -p(V_f - V_i) = -1.01 \times 10^5 \times (113 - 63) \times 10^{-6} \text{ J}$$

$$= -5.05 \text{ J.}$$

As the heat absorbed during the process $Q = 20.9 \text{ J}$, the change in the internal energy of the gas can be calculated using the first law of thermodynamics. It will be

$$\Delta E_{\text{int}} = Q + W = (20.9 - 5.05) \text{ J} = 15.9 \text{ J.}$$

(b)

The quantity of the gas is $n = 2.00 \times 10^{-3} \text{ mol}$. We can calculate the change in temperature of the gas using the ideal gas equation of state.

$$T_f - T_i = \frac{(p_f V_f - p_i V_i)}{nR} = \frac{p(V_f - V_i)}{nR} = \frac{5.05}{2.0 \times 10^{-3} \times 8.3315} \text{ K}$$

$$= 303.6 \text{ K.}$$

Therefore, the molar heat capacity at constant pressure of this ideal gas will be

$$C_p = \frac{Q}{n(T_f - T_i)} = \frac{20.9}{2.0 \times 10^{-3} \times 303.6} \text{ J mol}^{-1} \text{ K}^{-1}$$

$$= 34.4 \text{ J mol}^{-1} \text{ K}^{-1}.$$

(c)

Heat capacity at constant volume and the heat capacity at constant pressure are related as

$$C_p - C_v = R.$$

Therefore, the molar heat capacity at constant volume will be

$$C_v = C_p - R = 26.1 \text{ J mol}^{-1} \text{ K}^{-1}.$$

