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<u>Problem 25.41 (RHK)</u>

Let 20.9 J *of heat be added to a particular ideal gas. As a result, its volume changes from* 63.0 *to* 113 cm^3 *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.*

<u>Solution:</u>

(a)

The initial volume of the gas is

$V_i = 63.0\times10^{-6} \text{ m}^3.$

The final volume of the gas is

$V_f = 113\times10^{-6} \text{ m}^3.$

The work done on the gas at constant pressure

$p = 1.00 \text{ atm} = 1.01\times10^5 \text{ Pa}$ will be

$$W = -p\left(V_f - V_i\right) = -1.01\times10^5 \times\left(113-63\right)\times10^{-6}\ \text{J}$$
$$= -5.05\ \text{J}.$$

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

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

(b)

The quantity of the gas is $n = 2.00\times10^{-3}$ mol. We can calculate the change in temperature of the gas using the ideal gas equation of state.

$$T_f - T_i = \frac{\left(p_f V_f - p_i V_i\right)}{nR} = \frac{p\left(V_f - V_i\right)}{nR} = \frac{5.05}{2.0\times10^{-3}\times8.3315}\ \text{K}$$
$$= 303.6\ \text{K}.$$

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

$$C_p = \frac{Q}{n\left(T_f - T_i\right)} = \frac{20.9}{2.0\times10^{-3}\times303.6}\ \text{J mol}^{-1}\ \text{K}^{-1}$$
$$= 34.4\ \text{J mol}^{-1}\ \text{K}^{-1}.$$

(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

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