Answer on Question #74025-Physics-Molecular Physics-Thermodynamics

1. A gas expands adiabatically, and its volume doubles, while its absolute temperature drops 1.32 times. What is the number of degrees of freedom the gas molecules have?

Solution

$$TV^{\gamma-1} = const$$

$$\frac{T_2}{T_1} = \left(\frac{V_1}{V_2}\right)^{\gamma-1}$$

$$\frac{1}{1.32} = \left(\frac{1}{2}\right)^{\gamma-1}$$

$$2^{\gamma-1} = 1.32$$

$$\gamma = 1 + \log_2 1.32 = 1.4 = \frac{7}{5}$$

Thus, it is diatomic gas. Therefore, the gas molecules have 5 degrees of freedom.

2. Two identical systems each contain ν = 0.1 mole of an ideal gas at T = 300 K and p = 2.0 × 105 Pa. The pressure in the two systems is reduced by a factor 2, allowing the systems to expand, one adiabatically and one isothermally. What are the final temperatures and volumes of each system? Assume that γ = 5/3.

Solution

1) Adiabatic

$$pv = \nu RT$$

$$\frac{p}{2}v = \nu RT_f$$

$$p^{1-\gamma}T^{\gamma} = const \rightarrow T_f = T\left(\frac{1}{2}\right)^{\frac{\gamma-1}{\gamma}} = 300\left(\frac{1}{2}\right)^{\frac{5/3-1}{5/3}} = 227\ K$$

$$v = \frac{2\nu RT_f}{p} = \frac{2(0.1)(8.31)(227)}{2.0\ \cdot 10^5} = 0.0019\ m^3.$$

2) Isothermal

$$pv = \nu RT$$

$$\frac{p}{2}v = \nu RT$$

$$T = const \rightarrow T_f = 300\ K$$

$$v = \frac{2\nu RT}{p} = \frac{2(0.1)(8.31)(300)}{2.0\ \cdot 10^5} = 0.0025\ m^3.$$