Answer on Question 52206, Physics, Molecular Physics | Thermodynamics

Question:

A certain mass of a gas at $273K$ temperature and one atmospheric pressure is expanded to 3 times its original volume under adiabatic conditions. Calculate the resulting temperature and pressure. (Take the value of $\gamma = 1.4$)

Solution:

a) Let's write the mathematical equation for an ideal gas undergoing a reversible adiabatic process:

$$PV^{\gamma} = const, \ (1)$$

where, P is the pressure, V is the volume and $\gamma = 1.4$ is the adiabatic index.

Then we can write:

$$P_1 V_1^{\gamma} = P_2 V_2^{\gamma},$$

$$P_2 = P_1 \left(\frac{V_1}{V_2}\right)^{\gamma} = 1atm \cdot \left(\frac{1}{3}\right)^{1.4} = 0.215atm.$$

b) Since $P = n\frac{RT}{V}$, the above formula (1) implies that:

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

Then we can write:

$$T_1 V_1^{\gamma-1} = T_2 V_2^{\gamma-1},$$

$$T_2 = T_1 \left(\frac{V_1}{V_2}\right)^{\gamma-1} = 273K \cdot \left(\frac{1}{3}\right)^{0.4} = 176K.$$

Answer:

The resulting temperature and pressure would be:

a) $P_2 = 0.215atm.$

b) $T_2 = 176K.$