Answer on Question #45011 – Physics – Molecular Physics | Thermodynamics

Question.

One litre of nitrogen at 15 degree celsius and 10^6 Pa expands isothermally until its volume is doubled and then adiabatically until it is redoubled. Find the final pressure of gas.

$V_0 = 1\ l$

$T_0 = 15℃$

$P_0 = 10^6 Pa$

$V_1 = 2V_0$

$V_2 = 2V_1$

$P_2 = ?$

Solution.

The process $0 \to 1$ is isothermal. So, $T = const$.

We know the equation state of ideal gas:

$$PV = RT$$

For isothermal process we will receive:

$$PV = const$$

Therefore,

$$P_0V_0 = P_1V_1 = const \to P_1 = P_0\frac{V_0}{V_1}$$

The process $1 \to 2$ is adiabatic. So, let consider the adiabatic equation:

$$PV^\gamma = const$$

Therefore,

$$P_1V_1^\gamma = P_2V_2^\gamma = const \to P_2 = P_1\left(\frac{V_1}{V_2}\right)^\gamma = P_0\frac{V_0}{V_1}\left(\frac{V_1}{V_2}\right)^\gamma$$

It remains to find the adiabatic index γ. From the data sheets it is known that the adiabatic index of N_2 at $15℃$ is equal to 1.404. So, $\gamma = 1.404$.

Calculate:

$$P_2 = 10^6 \cdot \frac{1}{2} \cdot \left(\frac{1}{2}\right)^{1.404} = 10^6 \cdot 0.5 \cdot 0.378 = 0.189 \cdot 10^6\ Pa = 0.189\ MPa$$

Answer.

$$P_2 = P_0 \frac{V_0}{V_1}\left(\frac{V_1}{V_2}\right)^{\gamma} = 0.189 \cdot 10^6\ Pa = 0.189\ MPa$$