Answer on Question #67517-Physics-Mechanics-Relativity

An ideal monatomic gas undergoes an adiabatic compression from state 1 with pressure p1=1 atm, volume V1=8 L, and temperature T1=300 K to state 2 with pressure p2=32 atm, volume V2=1 L.

(a) What is the temperature of the gas in state 2?

(b) How many moles of gas are present?

(c) What is the average translational kinetic energy per mole before and after the compression?

(d) What is the ratio of the squares of the rms speeds before and after the compression?

(e) If we do not know that the ideal gas here is monatomic, demonstrate that the gas is truly monatomic.

Solution

(a)

$$T_2 = T_1 \frac{p_2}{p_1}\frac{V_2}{V_1} = 300\frac{32}{1}\frac{1}{8} = 1200\ K.$$

(b)

$$\nu = \frac{p_1 V_1}{RT_1} = \frac{101325 \cdot 0.008}{8.31 \cdot 300} = 0.325\ mol.$$

(c)

$$K_{before} = \frac{3}{2}kT_1 = \frac{3}{2}(1.38 \cdot 10^{-23})(300) = 6.21 \cdot 10^{-21} J.$$

$$K_{after} = \frac{3}{2}kT_2 = \frac{3}{2}(1.38 \cdot 10^{-23})(1200) = 2.48 \cdot 10^{-20} J.$$

(d) The ratio of the squares of the rms speeds before and after the compression is

$$\frac{T_1}{T_2} = \frac{300}{1200} = \frac{1}{4}.$$

(e) The adiabatic constant is

$$\gamma = \frac{\ln\frac{p_1}{p_2}}{\ln\frac{V_2}{V_1}} = \frac{\ln\frac{1}{32}}{\ln\frac{1}{8}} = \frac{5}{3}.$$

The adiabatic constant for monoatomic gas is

$$\gamma = \frac{C_p}{C_V} = \frac{\frac{5}{2}}{\frac{3}{2}} = \frac{5}{3}.$$

Thus, the gas is monoatomic.