Answer on Question#50646, Physics, Molecular Physics | Thermodynamics

Derive an equation of state pVγ = constant for an adiabatic process and show that an adiabat is steeper than an isotherm.

Answer

Let us use the first law of thermodynamics $\delta Q = C_V dT + PdV$ in order to derive an equation of state for adiabatic process. For an adiabatic process $\delta Q = 0$, thus $C_V dT = -PdV$. Substituting the equation of ideal gas for one mole $P = \frac{RT}{V}$ into the right side of the previous equation, obtain $C_V dT = \frac{-RT}{V} dV$, or $\frac{dT}{T} = \frac{-R}{C_V}\frac{dV}{V}$. Integrating from both sides, obtain $\ln\frac{T_2}{T_1} = \frac{-R}{C_V}\ln\frac{V_2}{V_1}$, or $\frac{T_2}{T_1} = \left(\frac{V_1}{V_2}\right)^{\frac{R}{C_V}}$ using the properties of logarithm. The last equation might be rewritten as $TV^{\frac{R}{C_V}} = const$ or $TV^{\gamma-1} = const$, where $\gamma = \frac{C_P}{C_V}$ (Here we also used $C_P = C_V + R$).

Using $T = \frac{PV}{R}$ and last equation, obtain $PV^{\gamma-1+1} = PV^{\gamma} = const$.

The equation of isotherm is $PV = const$, thus if $\gamma = \frac{C_P}{C_V} > 1$, the adiabat $PV^{\gamma} = const$ is obviously

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