Practice Problems - II

CML521: Molecular Thermodynamics

January 24, 2023

1. Show that for an ideal gas, the adiabatic PV curve is steeper than the isothermal one.

2. In an adiabatic setup, one mole of an ideal at an initial temperature of 400 K expands reversibly from 3 liters to 5 liters. The constant pressure heat capacity of the gas is 5 cal mol^{-1} K^{-1}. Calculate the work done and the enthalpy change during this process.

3. Imagine a cylinder fully isolated with insulating walls has a movable piston (weightless and frictionless) that can rattle inside. Initially, it equally partitions the cylinder into two halves each containing 1 mole of ideal gas at the same temperature of 300 K and pressure of 1 bar. One side of the cylinder has a heating coil inside that increases the temperature to 400 K. Assume that the cylinder walls and the piston have negligible heat capacity. Calculate the amount of heat added to the system in this process. The molar heat capacities of the gas are constant having values, C_P = 5 cal mol^{-1} K^{-1} and C_V = 3 cal mol^{-1} K^{-1}.

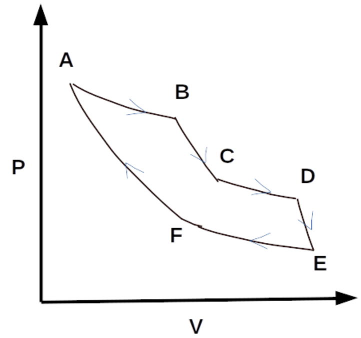

Figure 1: Caption

4. Imagine a cyclic process in which an ideal gas undergoes alternate isothermal and adiabatic processes as shown in the above diagram. The isothermal processes take place A-B at T1, C-D at T2, and E-F at T3, respectively. Calculate the efficiency of this cycle, if, in each isothermal expansion, the volume increases the same amount.

5. Suppose a gas obeys an equation of state, $P(V - b) = RT$; derive an expression for the work if one mole of the gas undergoes a reversible isothermal expansion from a volume V_1 to V_2. What would happen if the gas were an ideal gas? Explain.

6. The second law of thermodynamics states that heat flows from the hot reservoir (source) to the cold reservoir (sink). If the source and sink have temperatures T_H and T_C, respectively with the obvious condition $T_H > T_C$, prove that heat cannot flow from the sink to the source.

7. Calculate the efficiency of a heat engine working between temperatures 600 K and 300 K. Calculate the amount of work done and heat rejected to the low-temperature reservoir (sink). Draw a simple diagram of a heat engine and work out this problem.

8. One mole of water is heated reversibly from 27^oC to 37^oC. Calculate the entropy change. Comment on the sign of the entropy change. What would the value of ΔS be if the process follows a reversible adiabatic process?