[tex6] Retrievable and irretirievable energy put in heat reservoir

Consider the amount \( n = 1 \text{mol} \) of a monatomic classical ideal gas inside a cylinder with a piston on one side. This system is in thermal contact with a heat bath at temperature \( T_0 = 293 K \). An external work source pushes the piston from position 1 (\( V_1 = 5 m^3 \)) in to position 2 (\( V_2 = 3 m^3 \)) and then back out to position 1. Calculate the work \( \Delta W_{12} \) done by the source during step 1 \( \rightarrow \) 2 and the (negative) work \( \Delta W_{21} \) done during step 2 \( \rightarrow \) 1 under three different circumstances: Compression and expansion of the gas take place (a) quasi-statically, i.e. isothermally; (b) rapidly, i.e. adiabatically, and in quick succession; (c) adiabatically again, but with a long waiting time between the two steps.

For each case calculate also the energy \( E_W \) wasted in the heat bath after one full cycle. Find the highest temperature \( T_H \) and the lowest temperature \( T_L \) reached by the gas in case (c).

The equation of state is \( pV = nRT \), and the heat capacity is \( C_V = \frac{5}{2}nR \). During the adiabatic process: \( pV^\gamma = \text{const} \) with \( \gamma = \frac{5}{3} \).

Solution: