[tex3] Carnot cycle of the classical ideal gas

Consider the four steps of a Carnot engine with the operating material in the form of a classical ideal gas [$pV = nRT$, $U = C_V T$ with $C_V = \text{const}$].
(a) Determine the heat transfer, ΔQ, the work performance, ΔW, and the change in internal energy, ΔU, for each of the four steps:

$1 \to 2$ *isothermal expansion*: $T = T_H = \text{const}$, $V_2 > V_1$.
$2 \to 3$ *adiabatic expansion*: $S = \text{const}$, $V_3 > V_2$.
$3 \to 4$ *isothermal compression*: $T = T_L = \text{const}$, $V_4 < V_3$.
$4 \to 1$ *adiabatic compression*: $S = \text{const}$, $V_1 < V_4$.

(b) Sketch the Carnot cycle in the (V, p)-plane and in the (U, S)-plane.
(c) Show that the efficiency is $\eta_C = 1 - T_L/T_H$.

Solution: