[tex12] **Mayer's relation for the heat capacities of the classical ideal gas**

The amount $n = 1$mol of a classical ideal gas [$pV = nRT$, $U = C_V T$ with $C_V =$ const] is initially confined to a volume V_1 at pressure p_1.

In step $1 \to 2$ of Mayer's cycle (see Figure), the gas undegoes free expansion to volume V_2 while it is thermally isolated ($\delta Q = 0, \delta W = 0$) The pressure decreases from p_1 to p_2 during this step. In step $2 \to 3$ the gas is quasi-statically compressed back to volume V_1, while the pressure is maintained at p_2. With the temperature decreasing during this step, heat is expelled at the rate $\delta Q = C_p dT$. In step $3 \to 1$ the gas is heated up quasi-statically at constant volume V_1 ($\delta Q = C_V dT$) until the pressure returns to p_1.

Use the 1st law to derive Mayer's relation, $C_p - C_V = R$, between the heat capacities of the classical ideal gas. Both quantities are assumed to be constant.