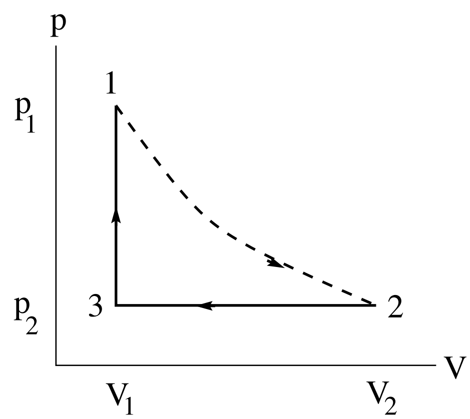
[tex12] Mayer's relation for the heat capacities of the classical ideal gas

The amount $n = 1\text{mol}$ of a classical ideal gas [$pV = nRT$, $U = C_V T$ with $C_V = \text{const}$] is initially confined to a volume V_1 at pressure p_1. In step $1 \to 2$ of Mayer's cycle, the gas undergoes 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. In step $3 \to 1$ the gas is heated up quasi-statically at constant volume V_1 until the pressure returns to p_1. Use the first law to derive Mayer's relation, $C_p - C_V = R$, between the heat capacities of the classical ideal gas.



Solution: