

# 1. **Joule Cycle.** A Joule cycle consists of two adiabats and two isobars:  $1 \rightarrow 2$  and  $3 \rightarrow 4$  are adiabatic compression and expansion, respectively;  $2 \rightarrow 3$  and  $4 \rightarrow 1$  are constant-pressure expansion and compression, respectively. Treat the working medium as an ideal gas with constant  $\gamma = C_p/C_V$ . Note that all the temperatures  $T_1, T_2, T_3, T_4$  and the volumes  $V_1, V_2, V_3, V_4$  are different.

a) Draw a P-V diagram illustrating the Joule cycle.

b) What is the heat absorbed,  $Q$ , during the process  $2 \rightarrow 3$ ?

c) Calculate the work done of a Joule cycle?

d) Compute the efficiency of this cycle in terms of  $\gamma$  and pressure ratio  $P_1/P_2$ , where  $P_1$  is the pressure at state 1 and  $P_2$  is the pressure at state 2. (HINT: make use of the fact that during an adiabatic process  $PV^\gamma = \text{const.}$  and  $TP^{(1-\gamma)/\gamma} = \text{const.}$ )