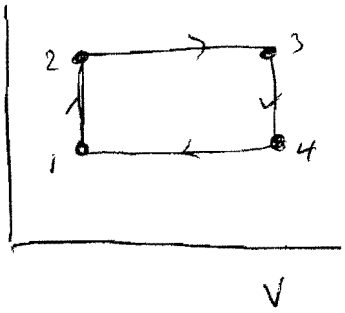
① 

$T_1 = 273\,K \quad V_1 = 1.00\times10^{-2}\,m^3 \quad P_1 = 2.27\times10^5\,Pa$

$T_2 = 298\,K \quad V_2 = V_1 = 1.00\times10^{-2}\,m^3$

$P_2 = \frac{nRT_2}{V_2} = 2.48\times10^5\,Pa$

$T_3 = 373\,K \quad P_3 = P_2 = 2.48\times10^5\,Pa$

$V_3 = \frac{nRT_3}{P_3} = 1.252\times10^{-2}\,m^3$

$T_4 = 340\,K \quad V_4 = V_3 = 1.252\times10^{-2}\,m^3$

$P_4 = \frac{nRT_4}{V_4} = 2.27\times10^5 = P_1$

$W_{12} = 0$

$Q_{12} = nC_v(T_2 - T_1) = 312\,J$

$W_{23} = -P(V_3 - V_2) = -625\,J$

$Q_{23} = nC_p(T_3 - T_2) = 1558\,J$

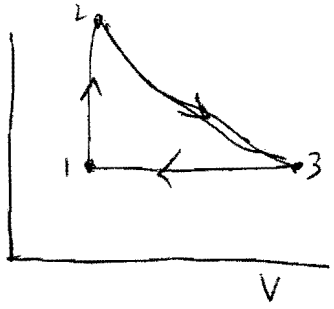
$W_{34} = 0 \qquad Q_{34} < 0$

$W_{41} = -P(V_1 - V_4) = +572\,J$

$|W_{net}| = |-625\,J + 572\,J| = 53\,J$

$Q_{in} = 1558\,J + 312\,J = 1870\,J$

$eff = \frac{53\,J}{1870\,J} = \underline{2.8\%}$

② 

$T_1 = 273\,K \quad V_1 = 1.00\times10^{-2}\,m^3 \quad P_1 = 2.27\times10^5\,Pa$

$T_2 = 373\,K \quad V_2 = V_1 = 1.00\times10^{-2}\,m^3$

$P_2 = \frac{nRT_2}{V_2} = 3.10\times10^5\,Pa$

$T_3 = T_2 = 373\,K$

$P_3 = P_1 = 2.27\times10^5\,Pa$

$V_3 = \frac{nRT_3}{P_3} = 1.366\times10^{-2}\,m^3$

$W_{12} = 0$

$Q_{12} = nC_v\Delta T = +1247\,J$

$W_{23} = -nRT\ln\frac{V_3}{V_2} = -967\,J$

$Q_{23} = -W_{23} = +967\,J$

$W_{31} = -P(V_1 - V_3) = +831\,J$

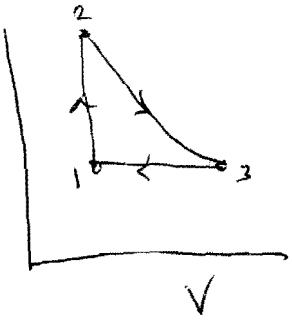
$Q_{31} < 0$

$|W_{net}| = |831\,J - 967\,J| = 136\,J$

$Q_{in} = 1247\,J + 967\,J = 2214\,J$

$eff = \frac{136\,J}{2214\,J} = \underline{6.1\%}$

(3)



$T_1 = 273\,K \quad V_1 = 1.00\times10^{-2}\,m^3 \quad P_1 = 2.27\times10^5\,Pa$

$T_2 = 373\,K \quad V_2 = V_1 = 1.00\times10^{-2}\,m^3$

$P_2 = \frac{nRT_2}{V_2} = 3.10\times10^5\,Pa$

$T_3 = 373\,K \quad P_3 = P_1 = 2.27\times10^5\,Pa$

$V_3 = \frac{nRT_3}{P_3} = 1.204\times10^{-2}\,m^3$

$W_{12} = 0$

$Q_{12} = nC_v(T_2 - T_1) = +1247\,J$

$Q_{23} = 0$

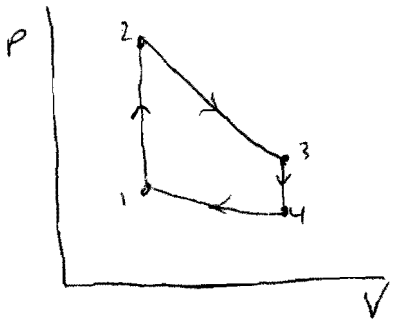
$W_{23} = \Delta E_{23} = nC_v(T_3 - T_2) = -548\,J$

$W_{31} = -P(V_1 - V_3) = +463\,J \qquad Q_{31} < 0$

$|W_{net}| = |463\,J - 548\,J| = 85\,J \qquad eff = \frac{85\,J}{1247\,J} = 6.8\%$

$Q_{in} = 1247\,J$

(4)



$T_1 = 273\,K \quad V_1 = 1.00\times10^{-2}\,m^3 \quad P_1 = 2.27\times10^5\,Pa$

$T_2 = 373\,K \quad V_2 = V_1 = 1.00\times10^{-2}\,m^3$

$P_2 = \frac{nRT_2}{V_2} = 3.10\times10^5\,Pa$

$T_3 = 284\,K \quad V_3 = 1.50\times10^{-2}\,m^3$

$T_4 = 273\,K \quad V_4 = V_3 = 1.50\times10^{-2}\,m^3$

$W_{12} = 0 \qquad Q_{12} = nC_v(T_2 - T_1) = +1247\,J$

$Q_{23} = 0 \qquad W_{23} = \Delta E_{23} = nC_v(T_3 - T_2) = -1109\,J$

$W_{34} = 0 \qquad Q_{34} < 0$

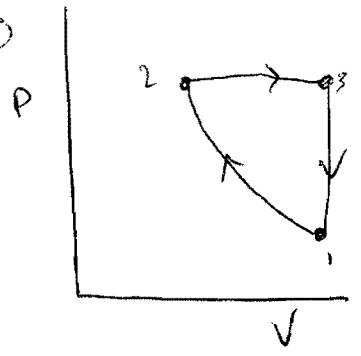
$W_{41} = -nRT\ln\frac{V_1}{V_4} = +920\,J \qquad Q_{41} < 0 \ (= -W_{41})$

$|W_{net}| = |-1109\,J + 920\,J| = 189\,J$

$Q_{in} = 1247\,J$

$eff = \frac{189\,J}{1247\,J} = 15.2\%$

(5)



$T_1 = 273\,K \quad V_1 = 1.00\times10^{-2}\,m^3 \quad P_1 = 2.27\times10^5\,Pa$

$T_2 = 273\,K \quad P_2 = P_3 = 3.10\times10^5\,Pa$

$V_2 = \frac{nRT_2}{P_2} = 0.732\times10^{-2}\,m^3$

$T_3 = 373\,K \quad V_3 = V_1 = 1.00\times10^{-2}\,m^3$

$P_3 = \frac{nRT_3}{V_3} = 3.10\times10^5\,Pa$

$W_{12} = -nRT\ln\frac{V_2}{V_1} = +708\,J$

$Q_{12} = -W_{12} = -708\,J$ (out)

$W_{23} = -P(V_3 - V_2) = -831\,J$

$Q_{23} = nC_p(T_3 - T_2) = +2078\,J$

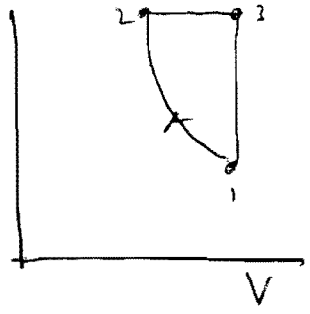
$W_{31} = 0$

$Q_{31} < 0$

$|W_{net}| = |-831\,J + 708\,J| = 123\,J$

$eff = \frac{123\,J}{2078\,J} = \underline{\underline{5.9\%}}$

(6)



$T_1 = 273\,K, \quad V_1 = 1.00\times10^{-2}\,m^3, \quad P_1 = 2.27\times10^5\,Pa$

$T_2 = 309\,K \quad P_2 = P_3 = 3.10\times10^5\,Pa$

$V_2 = \frac{nRT_2}{P_2} = 0.828\times10^{-2}\,m^3$

$T_3 = 373\,K \quad V_3 = 1.00\times10^{-2}\,m^3$

$P_3 = \frac{nRT_3}{V_3} = 3.10\times10^5\,Pa$

$Q_{12} = 0$

$W_{12} = \Delta E_{12} = nC_v(T_2 - T_1) = +449\,J$

$W_{23} = -P(V_3 - V_2) = -533\,J$

$Q_{23} = nC_p(T_3 - T_2) = +1330\,J$

$W_{31} = 0 \qquad Q_{31} < 0$

$|W_{net}| = |449\,J - 533\,J| = 84\,J$

$Q_{in} = 1330\,J$

$eff = \frac{84\,J}{1330\,J} = \underline{\underline{6.3\%}}$