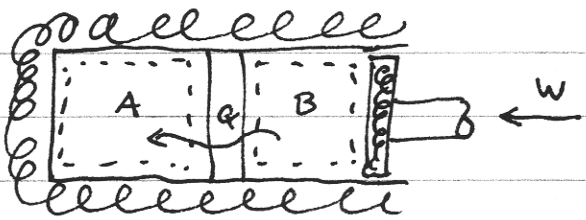
Q1 [Concepts: 1st law CM, eqn of state] 16. Unified Fall 08 ZS

a) 

Assume:
- quasi-equilibrium process
- ideal gas with constant spec. heats

state 1: $p_{A_1} = 5$ bar $p_{B_1} = 15$ bar state 2: $p_{A_2} = 16$ bar

$V_{A_1} = 0.01\,m^3$ $V_{B_1} = 0.01\,m^3$

$T_{A_1} = 573K$ $T_{B_1} = 573$ $T_{A_2} = T_{B_2}$ thermal equilibrium

b) A: isochoric compression (fixed volume, $p_A \uparrow$)

B: non-adiabatic compression (volume $\downarrow$, heat transferred)

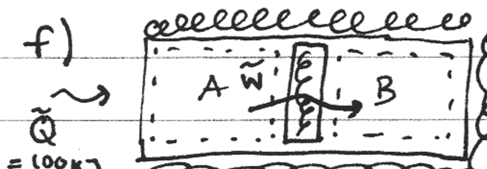
c) Isochoric compression in A use eqn. of state $p = \underbrace{\frac{mR}{V}}_{\text{const}} T \rightarrow$ $\underline{T_{A_2} = T_{B_2} = \frac{p_{A_2}}{p_{A_1}} T_{A_1} = 1{,}833.6K}$

d) 1st law A: $U_{A_2} - U_{A_1} = Q$; $m_A = \frac{p_{A_1}}{RT_{A_1}} V_{A_1}$, $Q = m_A c_v (T_{A_2} - T_{A_1})$

$c_p - c_v = R$, $\gamma = \frac{c_p}{c_v}$; $c_v = (\gamma-1)^{-1} R$; $m_A = 0.03$ kg $\underline{Q = 27.5\text{ KJ}}$

e) 1st law B: $U_{B_2} - U_{B_1} = -Q - (-W)$; but $U_{B_2} - U_{B_1} = m_B c_v (T_{B_2} - T_{B_1})$

$m_B = \frac{p_{B_1}}{RT_{B_1}} V_{B_1} = 0.09$ kg, $W = Q + m_B c_v (T_{B_2} - T_{B_1})$ $\underline{W = 110\text{ KJ}}$

f) 

Assume: - frictionless piston, adiabatic
- ideal gas with γ, R const

g) A: non-adiabatic exp. ($T\uparrow$, work done by sys)

B: adiabatic compr. ($T\uparrow$, $p\uparrow$, work done on sys)

state 1: $T_{A_1} = T_{B_1} = 300K$

$p_{A_1} = p_{B_1} = 2$ bar (mech. equil. always)

state 2: $T_{A_2} = 400K$

h) 1st law A: $U_{A_2} - U_{A_1} = \tilde{Q} - \tilde{W}$; $\tilde{W} = \tilde{Q} - \underbrace{m_A}_{1\text{kg}} c_v (T_{A_2} - T_{A_1})$, $\underline{\tilde{W} = 28.3\text{kJ}}$

$\tilde{W}$ = work done by sys A = work done on B

i) 1st law B: $U_{B_2} - U_{B_1} = -(-\tilde{W})$

so $T_{B_2} = \tilde{W} / (\underbrace{m_B}_{1\text{kg}} c_v) + T_{B_1}$ get $\underline{T_{B_2} = 339.4K}$