10.213  Problem #2

Solution:

\[ V_1^t = 0.624 \text{ m}^3 \]
\[ T_1 = 300K \]
\[ P_1 = 1 \text{ bar} \]
\[ V_2^t = 1.041 \text{ m}^3 \]
\[ T_2 = 500K \]
\[ P_2 = 1 \text{ bar} \]

\[ +Q = 104.2 \text{ kJ} \]

**Closed System**

**Isochoric Expansion**

Now, in general:

\[ W = -\int_{V_i}^{V_f} P_{op} dV^t \]

\[ W_{rev} = -\int_{V_i}^{V_f} P dV^t \]

for a reversible process

For constant \( P \),

\[ W_{rev} = -P \int_{V_i}^{V_f} dV^t \]

(a) From (i):

\[ W_{rev} = -P \int_{V_i}^{V_f} dV^t \]

\[ = -P \Delta V^t \]

\[ = (-1 \text{ bar})(1.041 - 0.624) \text{ m}^3 \left( \frac{10^5 \text{ Pa}}{1 \text{ bar}} \right) \]

\[ = -41.7 \text{ kJ} \]

\[ W_{rev} = -41.7 \text{ kJ} \]
(b) Work = -41.7 kJ < 0
Because work is done by system on surrounding during expansion.

(c) First Law:
\[ \Delta U^t = Q + W \]  \hspace{1cm} (S+VN 2.3)
\[ \Delta U^t = (104.2 \text{ kJ}) + (-41.7 \text{ kJ}) \]
\[ = +62.5 \text{ kJ} \]

(d) From definition of \( H_t \),
\[ H_t = U^t + PV^t \]  \hspace{1cm} (S+VN 2.5)
\[ \Delta H^t = \Delta U^t + \Delta (PV^t) \]  \hspace{1cm} (S+VN 2.7)
\[ = \Delta U^t + P \Delta V^t + V^t \Delta P \]
\[ = \Delta U^t + (\Delta W) \]
\[ = (+62.5 \text{ kJ}) - (-41.7 \text{ kJ}) \]
\[ = +104.2 \text{ kJ} \]
\[ \therefore \Delta H^t = +104.2 \text{ kJ} \]

(note: \( \Delta H^t = Q \) for isobaric process + reversible)
\[ \Delta H = \Delta H^t / n \]

\[ W = - \int PdV \]

(a) Work = \(-41.7 \text{ kJ} < 0\)

Because work is done by system on surrounding during expansion.

(c) First Law:

\[ \Delta U^t = Q + W \]

\[ \Delta U^t = (104.2 \text{ kJ}) + (-41.7 \text{ kJ}) = +62.5 \text{ kJ} \]

(d) From definition of \( H^t \):

\[ H^t = U^t + PV^t \]

\[ \Delta H^t = \Delta U^t + \Delta(PV^t) \] \[ = \Delta U^t + PA \Delta V^t + V^t \Delta P \]

\[ = \Delta U^t + (-W) \]

\[ = (+62.5 \text{ kJ}) - (-41.7 \text{ kJ}) = 0 \text{ for const. P} \]