GIVEN rigid tank $V = 2.0\ m^3$
>> initially $P_1 = 1$ bar, $T_1 = 295\ K$ (Air)
>> valve opened from vessel of $P_v = 6$ bar, $T_v = 295\ K$
>> final of tank $P_2 = 6$ bar, $T_2 = 350\ K$

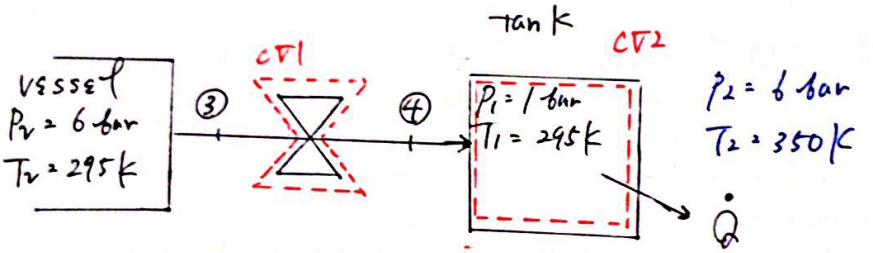
FIND $\dot{Q}$

ASSUMP open sys, uniform flow, ideal gas, $\Delta KE = \Delta PE = 0$, lumped mass, incompressible fluid, constant specific heat, no work, SF

EQN $\frac{dm}{dt}|_{sys} = \sum_i \dot{m} - \sum_e \dot{m}$, $\frac{dE}{dt}|_{sys} = \dot{Q} - \dot{W} + \sum_i \dot{m}(h + pe + ke) - \sum_e \dot{m}(h + pe + ke)$

$PV = mR_{air}T$ ($R_{air} = 0.287\ kJ/kg\cdot K$), $\Delta E = \Delta U + \Delta KE + \Delta PE$

EFD



SOLN first of all $m_1 = \frac{P_1 V}{R_{air} T_1} = \frac{(1\times10^2\ kPa)(2.0\ m^3)}{(0.287\ kJ/kg\,K)(295\ K)} \simeq 2.362\ kg$

$m_2 = \frac{P_2 V}{R_{air} T_2} = \frac{(6\times10^2\ kPa)(2.0\ m^3)}{(0.287\ kJ/kg\,K)(350\ K)} \simeq 11.95\ kg$

<CV1>
because this is a valve

$\frac{dE}{dt}|_{sys} = \dot{Q} + \sum_i \dot{m}h - \sum_e \dot{m}h \Leftrightarrow 0 = \dot{m}_3 h_3 - \dot{m}_4 h_4$

$\frac{dm}{dt}|_{sys} = \sum_i \dot{m} - \sum_e \dot{m} \Leftrightarrow \dot{m}_i = \dot{m}_e \Leftrightarrow \dot{m}_3 = \dot{m}_4$

So, $\dot{m}$ into tank is steady

<CV2>

$\frac{dU}{dt} = \dot{Q} + \dot{m}h \Leftrightarrow \frac{dU}{dt} = \frac{dQ}{dt} + h_i \frac{dm}{dt}$

$\int_{U_1}^{U_2} dU = \int_0^t \dot{Q}\,dt + h_i \int_{m_1}^{m_2} dm$

$U_2 - U_1 = Q_{12} + h_i(m_2 - m_1)$

$m_2u_2 - m_1u_1 = Q_{12} + h_i(m_2 - m_1)$

$\therefore Q_{12} = m_2u_2 - m_1u_1 - h_i(m_2 - m_1)$

since the air temp from the vessel is

$T_i = 295\,K$

$h_i = h|_{T=295K} = 295.1\ \text{kJ/kg}$ (from table)

and $u_1 = 210.5\ \text{kJ/kg}$

$u_2 = 250.0\ \text{kJ/kg}$ from table

$\therefore Q_{12} = (11.95\,\text{kg})(250.0\ \text{kJ/kg}) - (2.362\,\text{kg})(210.5\ \text{kJ/kg})$

$- (295.1\ \text{kJ/kg})(11.95\,\text{kg} - 2.362\,\text{kg})$

$\simeq -339.1\ \text{kJ}$

$Q_{12} = -339\ \text{kJ}$