(i)

GIVEN: Metal quenched in H_2O

$m_T = 1\ kg$, $T_1 = 1075\ K$, $c_T = 0.5\ kJ/kg\text{-}K$

$m_w = 100\ kg$, $T_{w1} = 295\ K$, $c_w = 4.2\ kJ/kg\text{-}K$

FIND (a) final equilibrium temp T_f, in (K)

(b) entropy produced in (kJ/K)

ASSUMP

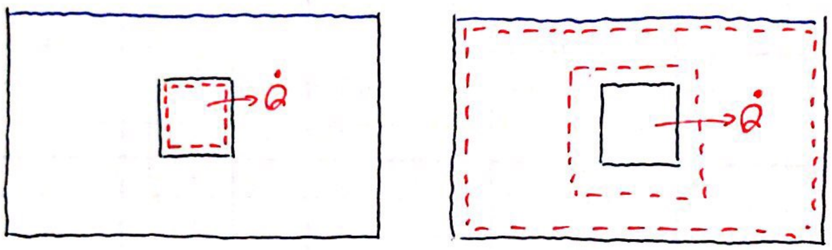
closed sys, $\Delta PE = \Delta KE = 0$, incompressible, constant specific heat, no work

EQN

$$\left.\frac{dm}{dt}\right|_{sys} = \cancel{\sum_i \dot{m}_i}^{\,0} - \cancel{\sum_e \dot{m}_e}^{\,0}, \quad \Delta U + \cancel{\Delta PE}^{\,0} + \cancel{\Delta KE}^{\,0} = Q - \cancel{W}^{\,0}$$

$$\Delta S_{sys} = \int_1^2 \frac{\delta Q}{T} + \sigma, \quad \Delta S_{sys} + \Delta S_{surr} = \sigma, \quad \Delta U = m c_v \Delta T$$

EFD



<i> <ii>

SOLN

(a) say the final equilibrium temperature is T_f
from conservation of internal energy

$$m_T c_T (T_1 - T_f) = m_w c_w (T_f - T_{w1})$$

$$m_T c_T T_1 - m_T c_T T_f = m_w c_w T_f - m_w c_w T_{w1}$$

$$(m_w c_w + m_T c_T) T_f = m_T c_T T_1 + m_w c_w T_{w1}$$

$$T_f = \frac{m_T c_T T_1 + m_w c_w T_{w1}}{m_w c_w + m_T c_T}$$

$$= \frac{(1\,kg)(0.5\,kJ/kg\text{-}K)(1075\,K) + (100\,kg)(4.2\,kJ/kg\text{-}K)(295\,K)}{(1\,kg)(0.5\,kJ/kg\text{-}K) + (100\,kg)(4.2\,kJ/kg\text{-}K)}$$

$$= \boxed{295.927\,K}$$

(b)

for EFD <i>

$$\Delta S = \int_1^2 \frac{\delta Q}{T} + \sigma = m_T C_T \ln \frac{T_f}{T_1} + m_w C_w \ln \frac{T_f}{T_{w1}}$$

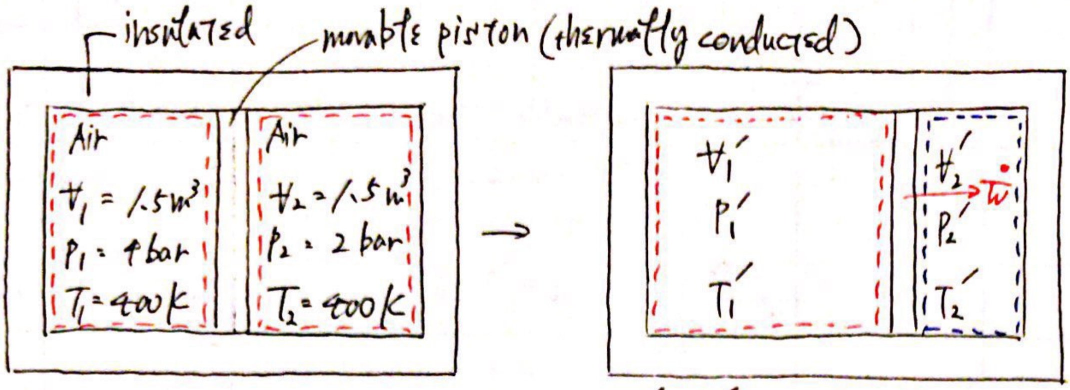
$$= (1\,kg)(0.5\,kJ/kg\text{-}K) \ln \frac{295.927}{1075} + (100\,kg)(4.2\,kJ/kg\text{-}K) \ln \frac{295.927}{295}$$

$$\approx \boxed{0.67275\ kJ/K}$$

19.

GIVEN

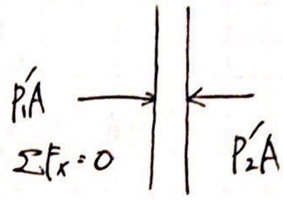
<EFD>



$T_1' = T_2'$ $P_1' = P_2'$

⇓

thermally conducted



FIND

(a) T_{final} (T_f) in K

(b) P_{final} ($P_1' = P_2' = P_f$) in bar

(c) σ_{gen} (kJ/K)

ASSUMP

closed sys, quasi-equilibrium, $\Delta KE = \Delta PE = 0$, ideal gas

EQN

$$\left.\frac{dm}{dt}\right|_{sys} = \sum_i \dot{m}_i - \sum_e \dot{m}_e, \quad \Delta U + \cancel{\Delta KE}^{0} + \cancel{\Delta PE}^{0} = Q - W$$

$$\Delta S = s_2^\circ - s_1^\circ - R\ln\frac{P_2}{P_1}, \quad PV = mRT \quad R_{air} = 0.287\ \frac{kJ}{kg\text{-}K}$$

SOLN

$$m_1 = \frac{P_1 V_1}{R_{air} T_1} = \frac{(4\times10^2 \text{ kPa})(1.5 m^3)}{(0.287 \frac{kJ}{kg\text{-}K})(400 K)} \simeq 5.226 \text{ kg}$$

$$m_2 = \frac{P_2 V_2}{R_{air} T_2} \simeq 2.613 \text{ kg} \qquad s_1^\circ|_{T=400} = 1.993 \text{ kJ/kg-K}$$

$$V_2' = 3.0 - V_1'$$

tabulated data

$$u_1 = u_2 = 286.1 \text{ kJ/kg}$$

$$P_1' = \frac{m_1 R_{air} T_1'}{V_1'} \quad \& \quad P_2' = \frac{m_2 R_{air} T_2'}{V_2'} \quad (\Rightarrow P_1' = P_2')$$

divide these two

$$\frac{m_1 T_1' V_2'}{m_2 V_1' T_2'} = 1 \iff \frac{(5.226 \text{ kg}) T_1' V_2'}{(2.613 \text{ kg}) T_2' V_1'} = 1$$

since $T_1' = T_2'$ & $V_2' = 3.0 - V_1'$

$$2(3.0 - V_1') = V_1'$$

$$6.0 - 2V_1' = V_1' \qquad V_1' = 2.0 m^3$$

then $V_2' = 1.0\,m^3$

the internal energy does not change inside box thus. $\longrightarrow$ $\boxed{T_f = 400\,K}$

(b) $p_2' = p_f = \dfrac{m_2 R_{air} T_2'}{V_2'} = \dfrac{(2.613\ kg)(0.287\ kJ/kg\text{-}K)(400\,K)}{1.0\,m^3}$

$\cong 3.00$ bar

$p_1' = p_2'$

$\boxed{p_f = 3.00\ bar}$

(c)

$\Delta S = m_1 R_{air} \ln \dfrac{V_1'}{V_1} + m_2 R_{air} \ln \dfrac{V_2'}{V_2}$

$= (5.226\,kg)(0.287\ kJ/kg\text{-}K) \ln\left(\dfrac{2.0}{1.5}\right) + (2.613\ kg)(0.287\ kJ/kg\text{-}K) \ln\left(\dfrac{1.0}{1.5}\right)$

$\cong \boxed{0.12742\ kJ/K}$