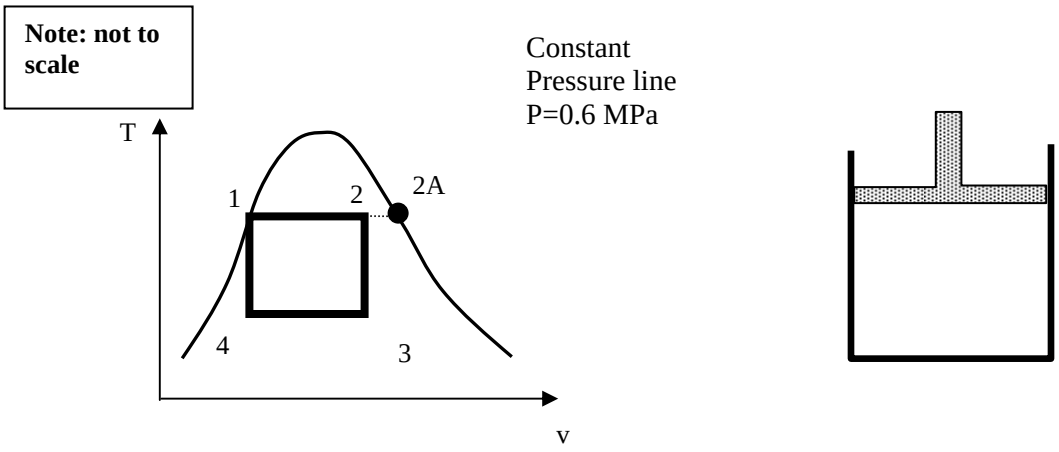
EML 3002 ME Tools Example 3

1. A piston/cylinder assembly (with an initial pressure, $P_1=P_2=0.6$ MPa) contains 1 kg of 100% saturated liquid water as shown. The system is undergoing through four processes 1-2-3-4-1 as indicated on the T-v diagram. 1-2 and 3-4 are constant pressure processes; 2-3 and 4-1 are constant volume processes.
   (a) Determine the quality at state 2 ($x_2$) if 180 kJ of work is done by the expansion process from 1 to 2.
   (b) Determine the total amount of the heat transfer required to completely vaporize all water in the cylinder into 100% saturated water vapor (still under constant pressure condition, $P_1=P_{2A}$ from 1 to 2A and $x_{2A}=1.0$).




Saturated State

$v = v_f + x(v_g - v_f)$

The same formular for other thermodynamic properties such as internal energy $u$ and enthaply $h$

$\Delta U_{AB} = U_B - U_A = Q_{AB} - W_{AB}$

Solution:

$(a)\ 180 = W_{12} = \int PdV = P(V_2 - V_1) = mP(v_2 - v_{f\,@\,P=0.6MPa}) = (1)(600)(v_2 - 0.001101),\ v_2 = 0.3(m^3/kg)$

$v_2 = v_f + x_2(v_g - v_f),\ \ x2 = \dfrac{v_2 - v_f}{v_g - v_f} = \dfrac{0.3 - 0.001101}{0.3157 - 0.001101} = 0.95$

$(b)\ \Delta U_{12} = U_2 - U_1 = Q_{12} - W_{12} = Q_{12} - P(V_2 - V_1),$

$Q_{21} = H_2 - H_1 = m(h_g - h_f) = (1)(2756.8 - 670.6) = (1)(2086.2) = 2086.2(kJ)$