[tex156] Triple point phase changes II

A cylinder with vertical axis has insulating and rigid walls and is capped by an insulating piston. The cylinder contains $m_s^{(0)} = 1$g of ice, $m_l^{(0)} = 2$g of water, and $m_g^{(0)} = 5$g of H_2O vapor in thermal equilibrium. All four processes described below start from this state. Assume that the difference in densities between the liquid and solid phases is negligibly small.

(i) The piston stays at rest. How much heat ΔQ_1 can be added before the temperature begins to increase? What are the masses $m_s^{(1)}, m_l^{(1)}, m_g^{(1)}$, of ice, water, and vapor, respectively, at that point?

(ii) The piston stays at rest. How much heat ΔQ_2 can be extracted before the temperature begins to decrease? What are the masses $m_s^{(2)}, m_l^{(2)}, m_g^{(2)}$, of ice, water, and vapor, respectively, at that point?

(iii) There is no heat transfer. How much (positive) work ΔW_3 can the piston do onto the gas (by moving in) before the temperature begins to increase? What are the masses $m_s^{(3)}, m_l^{(3)}, m_g^{(3)}$, of ice, water, and vapor, respectively, at that point?

(iv) There is no heat transfer. How much (negative) work ΔW_4 can the piston do onto the gas (by moving out) before the temperature begins to decrease? What are the masses $m_s^{(4)}, m_l^{(4)}, m_g^{(4)}$, of ice, water, and vapor, respectively, at that point?

Triple point temperature: $T = 273$K.
Triple point pressure: $p = 611\text{N/m}^2$.
Latent heat of melting: $L_{sl} = 335$J/g.
Latent heat of vaporization: $L_{lg} = 2495$J/g.

Solution: