Thermodynamics - 1

An isolated system of total mass m is formed by mixing a liquid of mass $m/4$ at temperature T_1 with a mass of $\frac{3}{4}m$ of the same liquid at temperature T_2. Eventually, the system attains thermodynamic equilibrium. You can assume the liquid is incompressible with a constant value of specific heat c.

i) Make a sketch of the system showing the initial state and the final state. Clearly identify your choice for the system boundary and indicate all variables of relevance. **(15 points)**

ii) Starting from the First Law of Thermodynamics for a closed system

$$\Delta E = Q - W$$

derive an expression for the final equilibrium temperature of the liquid T_f. Arrange your answer for the T_f to be only in terms of T_1 and T_2. **(30 points)**

iii) Starting from the Second Law of Thermodynamics for a closed system

$$\Delta S = \int_1^2 \left(\frac{\delta Q}{T} \right)_b + \sigma$$

derive an expression for the amount of entropy produced σ. Arrange your answer for σ to be only in terms of m, c, T_1, and T_2. **(40 points)**

iv) Under what conditions (if any) for T_1 and T_2 will the following statements be true. Provide an explanation for each case and provide quantitative support for your discussion. **(15 points)**

Case 1: $\sigma > 1$

Case 2: $\sigma < 0$

Case 3: $\sigma = 0$