Thermodynamics - 1

An insulated and rigid tank of total volume 0.8 m^3 is initially divided into two compartments separated by a partition. One compartment contains 0.5 m^3 of hydrogen (H_2) at 127 °C and 3 bar and the other compartment contains nitrogen (N_2) at 27 °C and 5 bar. The partition is removed and the gases are allowed to mix until thermodynamic equilibrium is reached. You can treat the hydrogen and nitrogen as ideal gases with constant values of the specific heat.

Additional information: universal gas constant $\bar{R} = 8.314 \frac{\text{kJ}}{\text{kmol K}}$, molecular weight of hydrogen $\text{M}_{\text{H}_2} = 2.016 \frac{\text{kg}}{\text{kmol}}$, molecular weight of nitrogen $M_{N_2} = 28.01 \frac{\text{kg}}{\text{kmol}}$, specific heat of hydrogen $c_{v,H_2} = 10.302 \frac{\text{kJ}}{\text{kg K}}$, specific heat of nitrogen $\text{c}_{\text{v,N}_2} = 0.744 \frac{\text{kJ}}{\text{kg K}}$, $1 \text{ bar} = 10^5 \text{ Pa}$.

(i) (**20 points**) Starting from the First Law of Thermodynamics determine the final temperature T_f of the mixture. Give your answer in units of °C.

(ii) (**20 points**) Determine the final pressure p_f of the mixture. Give your answer in units of bar.

(iii) (**40 points**) Starting from the Second Law of Thermodynamics determine the amount of entropy produced σ by going from the initial state to the final state. Give your answer in units of $\frac{\text{kJ}}{\text{K}}$.

(iv) (**10 points**) Imagine conducting the same experiment where the pressure and temperature of the nitrogen in the second compartment is set to equal that of the hydrogen in the first compartment. Specifically, one compartment initially contains 0.5 m^3 of hydrogen (H_2) at 127 °C and 3 bar and the other compartment initially contains nitrogen (N_2) at 127 °C and 3 bar. The partition is removed and the system is allowed to reach thermodynamic equilibrium. Determine the amount of entropy produced σ for this case.

(v) (**10 points**) Did the entropy production increase, decrease, or stay the same by adjusting the pressure and temperature on the nitrogen in the second compartment? In a sentence or two provide some physical justification to support your finding.