Grading: 35 points. If the assignment is submitted to Isidore after the due date without a valid reason (to be discussed with professor well before due date) then 50% will be **automatically** deducted from the assignment.

All work should be submitted as a well-written, concise report with all equations presented using an equation editor (Word equation editor, Latex, or MathType suggested). Submit a .pdf of all of your work to Isidore and submit any MATLAB / EXCEL files used during calculations as a file submission (codes will be tested to ensure they run). No plagiarism is permitted. If plagiarism is discovered, an automatic 0 for the assignment will be applied.

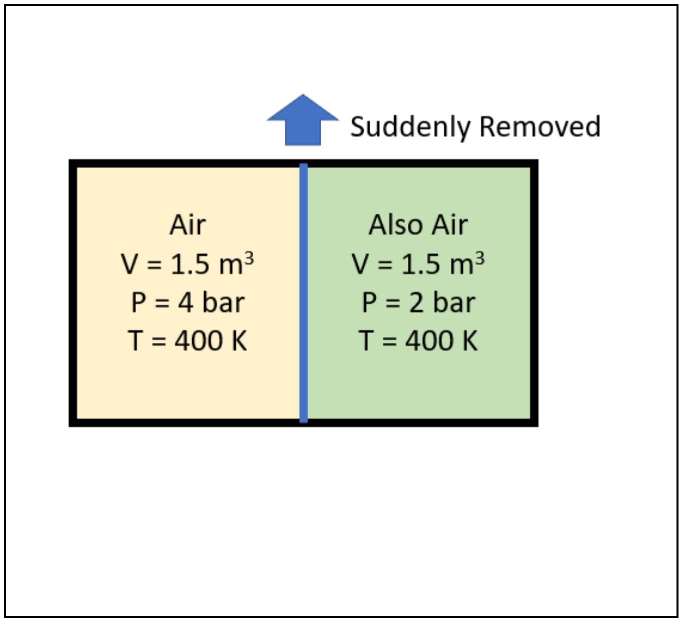
Entropy and Ideal Gas Components

1. The specific heat ratio is defined as $k = C_p/C_v$. Based on what you know regarding the differences between the types of specific heats do you anticipate it to be greater than, equal to, or less than one. Why?

2. Using the T-ds equations and ideal-gas relationships and assuming constant specific heats, derive the predictive relationships for the performance of isentropic compressors / turbines for ideal gases. Additionally comment on the weaknesses of this prediction and where you would differ

$$\frac{T_2}{T_1} = f(P_2, P_1, k)\,, \frac{T_2}{T_1} = f(v_2, v_1, k), \frac{P_2}{P_1} = f(v_1, v_2, k)$$

3. An insulated box is initially divided into two halves by a frictionless, thermally conductive actuated wall. The piston is suddenly released and equilibrium between the two gases is fully attained.



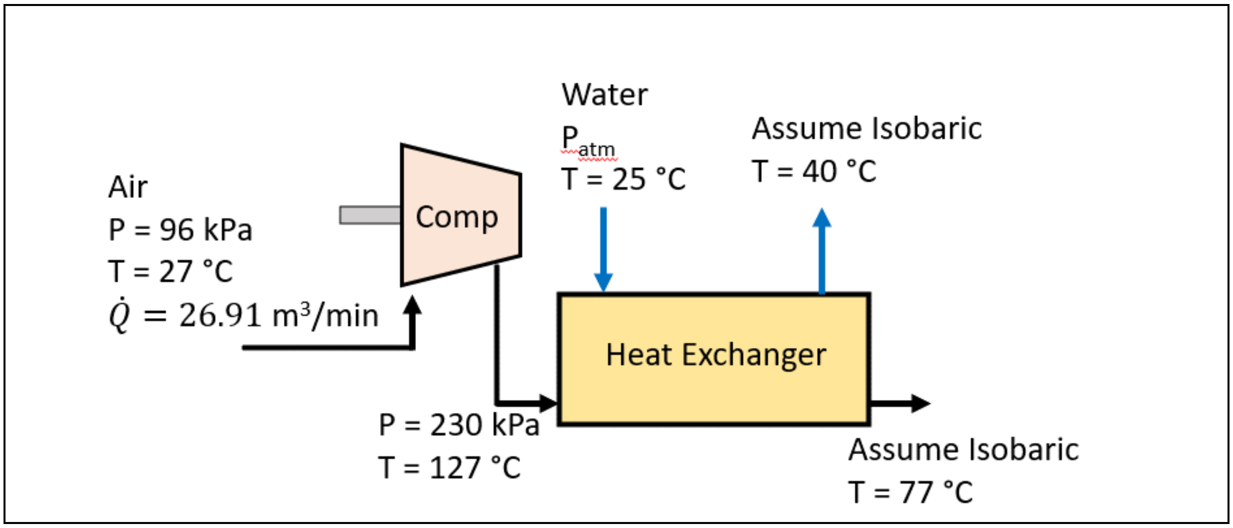
Part A: Determine the final temperature in K

Part B: Determine the final pressure in bar

Part C: Determine the quantity of energy production

Part D: Comment on what caused this entropy production to occur.

4. Air flows through a compressor and heat exchanger. A separate liquid water stream also flows through the heat exchanger. The system operates at pseudo-steady state. Assume individual components are well insulated relative to the environment.



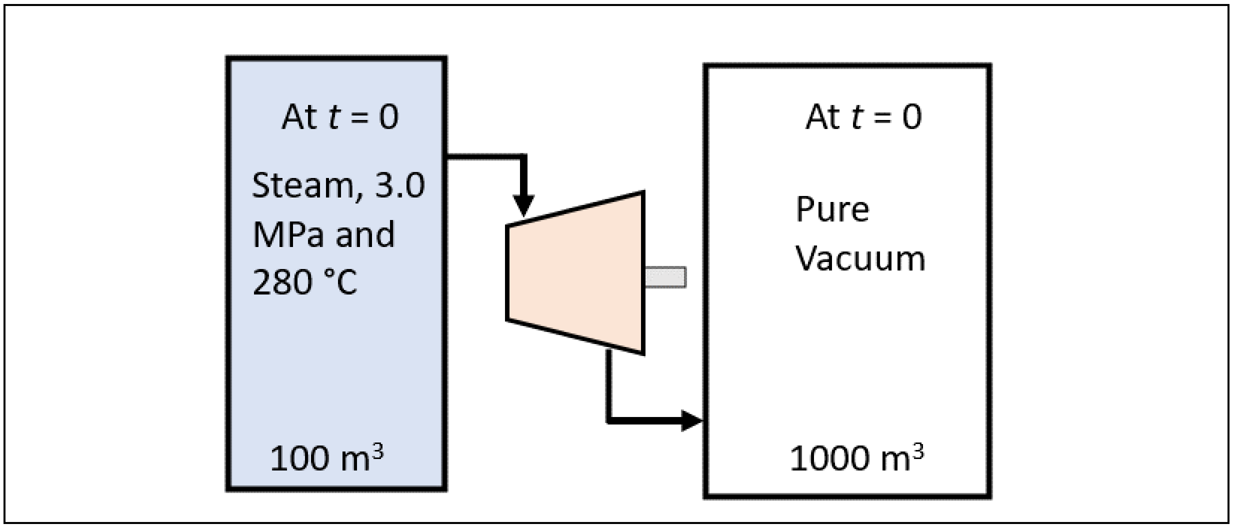
PART A: Determine the required compressor power and the mass flow rate of cooling water

PART B: Determine the entropy production rates for the compressor and heat exchanger

PART C: Comment on what caused this entropy production to occur.

Entropy and Other Things

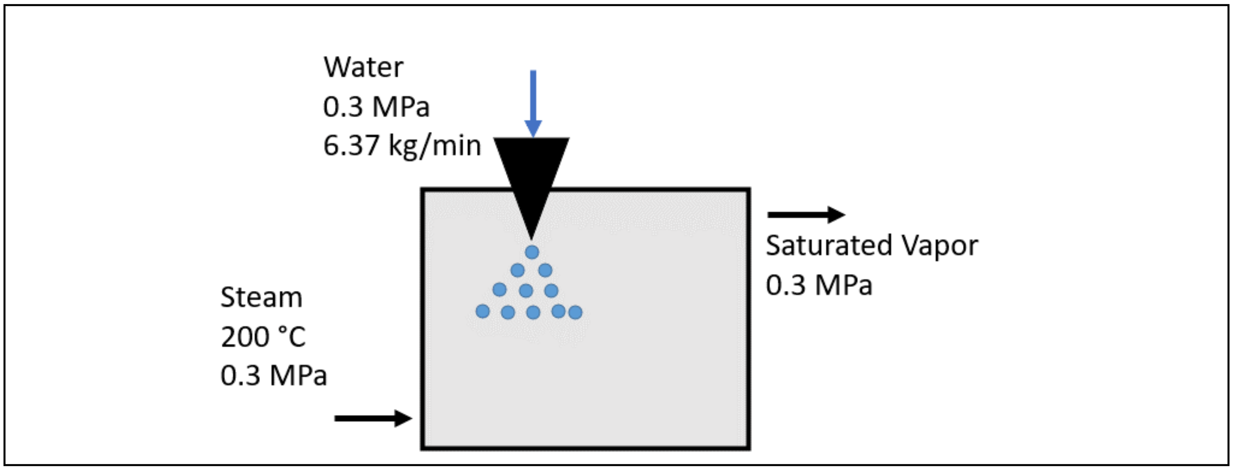
5. A turbine is located between two tanks. Initially the smaller tank is pressurized while the larger tank is fully evacuated. Assume the heat transfer with the surroundings is negligible. Steam is allowed to flow from the smaller tank, through the turbine, and into the larger tank until equilibrium is attained. If the turbine is ideal during its expansion process, determine:



PART A: What are the equilibrium conditions in both tanks (*T*,*P*,*m*,).

PART B: Determine the **maximum quantity** of theoretical work that could be extracted from the turbine.

6. Liquid water is injected into a superheated vapor to produce a saturated vapor.

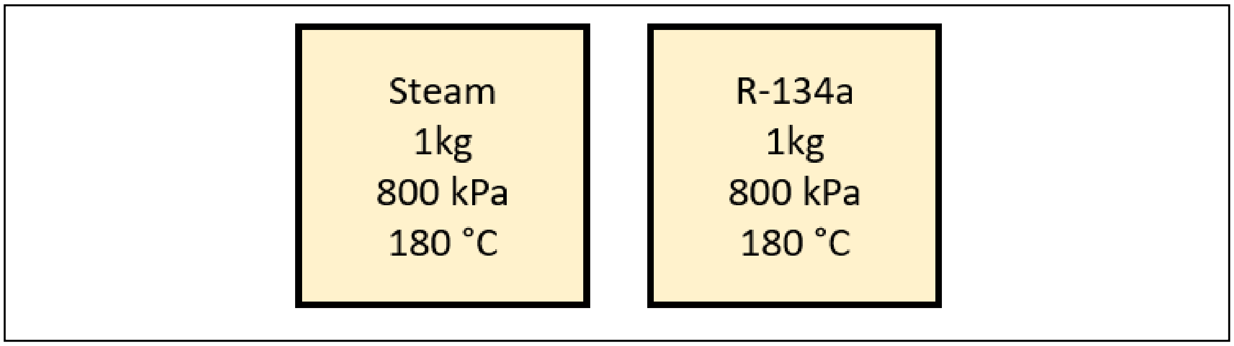


PART A: Determine the mass flow rate of the superheated vapor stream

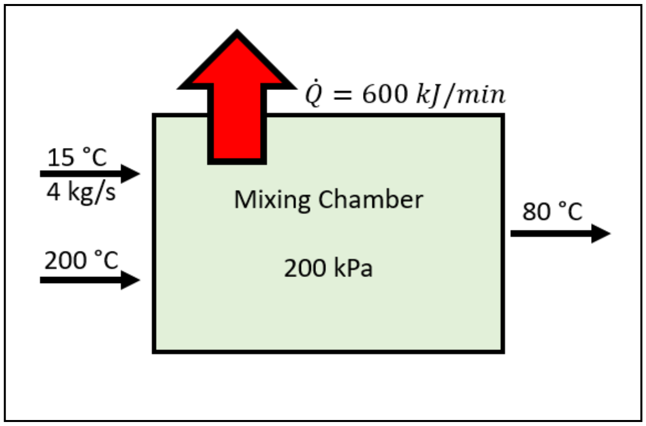
PART B: Determine the rate of entropy production within the system.

Exergy

7. Which of the two materials below have the capability to produce the most work in a closed system if taken to an environmental dead state of 25 °C and 100 kPa?



8. Liquid water is heated using a mixing chamber that combines it with superheated steam at a constant pressure. Heat loss to the environment is tracked.



PART A: Determine the mass flow rate of the superheated steam.

PART B: Determine the rate of lost work potential caused by this mixing process.

9. The temperature of the air in a building can be maintained at a desirable level during winter by using different methods of heating. Compare indirectly heating this air in a heat exchanger unit with condensing steam to heating the air directly via an electric resistance heater. Play with exergy analyses to prove which heating method results in the least exergy destruction method. You will need to perform some research regarding temperatures and operating characteristics of these systems.