

## HW – 27: Evaluating Entropy Changes

**Answer the following questions. No need to follow the formal solution procedure.**

- i) List the minimum set of assumptions required to employ each of the following equations. Possible assumptions include: closed system, open system, steady state, adiabatic, no work, negligible changes in potential energy, negligible changes in kinetic energy, isothermal, constant pressure, incompressible, ideal gas, constant specific heats, internally reversible. Show how any simplified equations are developed from basic equations that appear on your equation sheet when applying the specified assumptions.

$$\Delta s_{12} = c \cdot \ln \frac{T_2}{T_1}$$

$$\Delta s_{12} = \int_{T_1}^{T_2} c_p \frac{dT}{T} - R \cdot \ln \frac{P_2}{P_1}$$

$$\Delta s_{12} = s_2^\circ - s_1^\circ - R \cdot \ln \frac{P_2}{P_1}$$

$$\Delta s_{12} = \frac{1}{m} \int_1^2 \frac{\delta Q}{T}$$

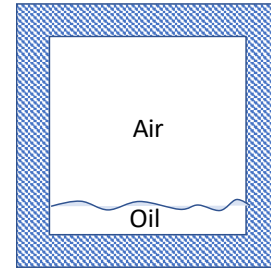
- ii) Which of the following is applicable for determining the specific entropy change of a two-phase mixture between two known states that has undergone a quasi-equilibrium, constant temperature heat transfer process with no frictional effects in a closed system? Explain.

a)  $\Delta s_{12} = \frac{1}{m} \int_1^2 \frac{\delta Q}{T}$ , b)  $\Delta s_{12} = \frac{1}{m} \frac{Q_{12}}{T}$ , c) property tables, d) a, b, and c give the same result

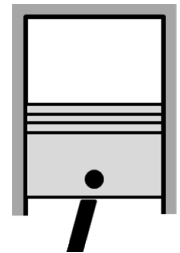
- iii) Liquid water treated as an incompressible substance undergoes a process whereby its pressure is raised but its temperature remains constant. Does its entropy increase, decrease, or remain the same? Justify using appropriate equations!
- iv) A fixed mass of an ideal gas is heated from 40 to 60°C at a constant pressure of (a) 100 kPa and (b) 300 kPa. For which case will the entropy change be greater? Use thermodynamic relations to explain.
- v) A fixed mass of an ideal gas is heated from 40 to 60°C at a constant volume of (a) 1 m<sup>3</sup> and (b) 3 m<sup>3</sup>. For which case will the entropy change be greater? Use thermodynamic relations to explain.
- vi) A fixed mass of an ideal gas is heated from 40 to 60°C (a) at constant volume and (b) at constant pressure. For which case will the entropy change be greater? Use thermodynamic relations to explain.
- vii) Compare the specific entropy change of air (treated as an ideal gas) that is heated from 300 K to 500 K in a rigid, closed container as determined using 3 different approaches: a) ideal gas tables for air, b) constant specific heat for air evaluated at the average temperature, c) constant specific heat for air evaluated at the initial temperature.

## HW – 28: Entropy Generation for Closed Systems

- i) Consider the balloon in HW-12i (Week 5) that contains air in an environment at  $0^\circ\text{C}$  and then is moved indoors where the temperature is  $20^\circ\text{C}$ . Using the result for heat transfer from the posted solution for HW-12i as given information, then determine the total entropy generation, in J/K. You can assume constant specific heats. Be sure to follow the formal solution procedure, but only include a system definition, assumptions and basic equations that are relevant to this part of the problem. Show the process for the air on a T-s diagram with appropriate lines of constant pressure.
- ii) Consider the problem of HW-13i where liquid oil is injected into an enclosed, well-insulated, and rigid chamber that contains air. Using the given initial conditions for the oil and air along with the final equilibrium temperature ( $^\circ\text{C}$ ) and pressure (kPa) from the solution for HW-13i, determine the total entropy generation, in kJ/K. You can assume negligible contributions of the chamber material, oil remains as a liquid and its volume is negligible compared to the air, constant specific heats, and the specific heat for oil is  $1.7 \text{ kJ/kg}\cdot\text{K}$ . Be sure to follow the formal solution procedure, but only include a system definition, assumptions and basic equations that are relevant to this part of the problem.
- iii) Consider compression of air treated as an ideal gas ( $R = 0.287 \text{ kJ/kg}\cdot\text{K}$ ) in a closed piston cylinder device with initial conditions of  $P_1 = 1 \text{ bar}$ ,  $T_1 = 300 \text{ K}$ , and  $V_1 = 0.0005 \text{ m}^3$ . At the end of the compression stroke,  $P_2 = 18.65 \text{ bar}$ . Use an entropy balance to determine a) the final temperature ( $T_2$ , K) after compression if the process is adiabatic and internally reversible and b) the total heat transfer ( $Q_{12}$ , kJ) for the compression process if it is isothermal ( $T_2 = T_1 = T = 300 \text{ K}$ ) and internally reversible. Assume variable specific heats for air in part a. For part b, compare your result with the heat transfer that you would determine from an energy balance with boundary work. Show the two processes on a T-s diagram with appropriate lines of constant pressure.

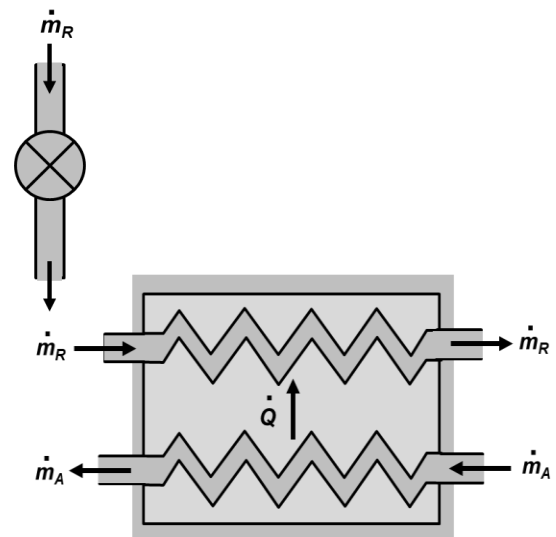


$$\begin{aligned} m_{\text{air}} &= 1.1 \text{ kg} \\ T_{\text{air},1} &= 200^\circ\text{C} \\ P_1 &= 200 \text{ kPa} \\ m_{\text{oil}} &= 0.5 \text{ kg} \\ T_{\text{oil},1} &= 50^\circ\text{C} \\ T_2 &= 17^\circ\text{C} \end{aligned}$$

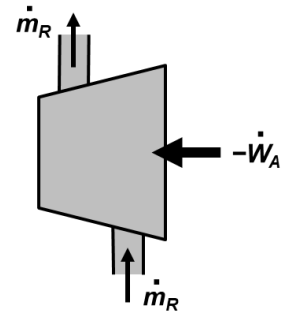


## HW – 29: Entropy Generation for Steady-State Open Systems and Cycles

- i) Consider the combination of the throttling valve and indoor heat exchanger for the propane air conditioner of HW-16i and HW-16ii (Week 6). Using the given and calculated conditions for the propane and air from the posted solution, determine the total rate of entropy generation for this combined system, in kW/K. Depict the process for the propane on a T-s diagram showing the dome, appropriate lines of constant pressure, and labeled state points. Note that you can use a single system definition for the throttling valve and heat exchanger that includes both the propane and air flow streams. Also, you can neglect pressure drop within the heat exchanger for both the air and refrigerant.



- ii) Consider the compressor for the propane air conditioner of HW-16iii. Using the given and calculated conditions for the propane from the posted solution, then determine the total rate of entropy generation, in kW/K. Assume that the compressor is located in an environment that is at a temperature of 42°C. Depict the process for the propane on a T-s diagram showing the dome, appropriate lines of constant pressure, and labeled state points. Now consider a case where the compressor is adiabatic and internally reversible. Determine the exit temperature, in K, with the same exit pressure of 18 bar. Depict this ideal process on the same T-s diagram.



- iii) Now consider the entropy generation for the entire propane air conditioner of HW-16. Assume that the air conditioner cools a space at 20°C and has a heat transfer to an ambient at 42°C. Consider the complete cycle as a closed system and determine the rate of entropy generation, in kW/K. Use the given and calculated energy transfer rates from the posted solution for HW-16.