AREN 2110: Thermodynamics
Spring 2011

HOMEWORK 9: Due Friday, April 8, 6 PM (11 problems, 40 points possible)

1. (2 points) Give an example of an isothermal process that is internally reversible and adiabatic.

2. (2 points) Give an example of an isothermal process that is internally reversible.

3. (2 points) Work is not associated with entropy. Will the entropy of steam passsing through an adiabatic turbine always be constant? Why/Why not?

4. (2 points) Under what conditions is it possible for the entropy change of a closed system to equal zero during an irreversible process?

5. (2 points) When a process is adiabatic, what can be said about the entropy change of the system?

6. (3 points) 100 kJ of heat is transferred from a high-temperature reservoir at 1200K to a low-temperature reservoir at 600K. Calculate the rate of entropy change (kw/K) for the two reservoirs and show that the Clausius principle is satisfied for the system.

7. (5 points, 3 for a and 2 for b) A completely reversible heat pump provides 100 kw heat to a house maintained at 21 ^{o}C. Heat is transferred from outside air at 10 ^{o}C.

    a. Calculate the rate of entropy change (kw/K) for the high- and low-temperature reservoirs.
    b. Show that the Clausius principle for the refrigeration cycle is satisfied.

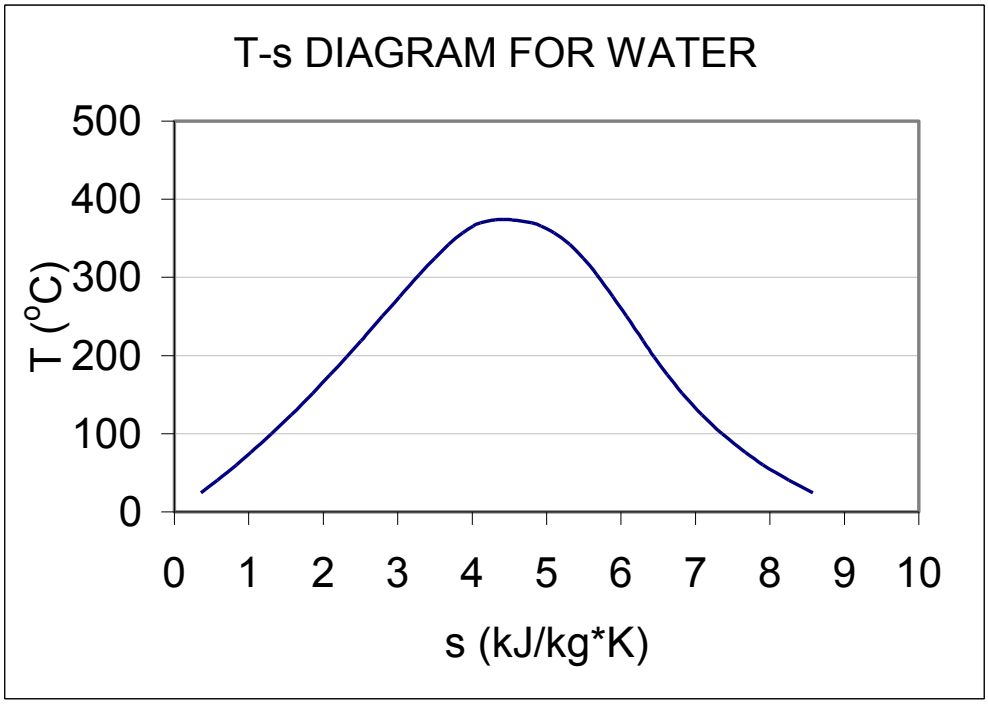
8. (3 points) A well insulated rigid tank contains 2 kg of water as a mixture of liquid and vapor at 100 kPa and x = 0.25. An electric heater is turned on until all the water has been converted to saturated vapor.
    a. Calculate the entropy change of the system (kJ/K)
    b. What is the entropy generated in the surroundings (kJ/K)?

9. (4 points, 2 per part) Steam enters a reversible compressor at 50 kPa and 150 ^{o}C. There is no heat transfer during the compression process, and steam leaves the compressor at 300 kPa.
    a. What is the temperature of the steam at the outlet?
    b. What is the work input to the compressor?

10. (8 points, 2 per part) A piston-cylinder device contains 5 kg water as a liquid-vapor mixture at 100 ^{o}C with a quality of 0.5. Two process occur in sequence:

    1→ 2: heat addition from a reservoir at 200 ^{o}C until the steam is saturated vapor
    2→3: adiabatic and reversible expandion until the pressure is 15 kPa.

a. Draw the process on the T-s diagram below



b. Determine the heat transfer in process 1→ 2 in kJ.

c. Determine the work done in process 2→3 in kJ.

d. What is the change in entropy in the surroundings for the two-step process in kJ/K?

11. (7 points, 3 for a and 2 each for b and c) A heat pump design is proposed that provides 25 kw heat while consuming 5 kw lectrical power. The high- and low-temperature reservoirs are 300K and 260K, respectively.

    a. Show that the cycle satisfies Clausius' principle.
    b. Show that the cycle satisfies Carnot's principle.
    c. What is the entropy produced in the surroundings (kw/K)?