AREN 2110: Thermodynamics
Spring 2011

HOMEWORK 10: Due Friday, April 15, 6 PM (12 problems, 45 points possible)

1. (4 points, 1 per part) Ten grams of computer chips with a specific heat of 0.3 kJ/kg-K initially at 20 ^{o}C are cooled by putting them in 5 grams of saturated liquid R-134a at – 40 ^{o}C. Assuming the pressure is constant during the cooling process, calculate:
    a. the entropy change of the chips
    b. the entropy change of the R-134a
    c. the entropy change of the system
    d. if this process is possible

2. (4 points, 3 for a, 1 for b) An insulated rigid tank is divided into two equal parts by a partition. One half contains 5 kmol of an ideal gas at 250 kPa and 40 ^{o}C, and the other side is evacuated. The particion is removed and the gas fills the entire tank. a) What is the total entropy change during the process? b) Is it reversible?

3. (3 points) An insulated rigid tank contains 4 kg argon gas at 450 kPa and 30 ^{o}C. A valve is now opened, and argon is released until the pressure in the tank drops to 200 kPa. Assuming the argon in the tank has undergone a reversible adiabatic process, determine the final mass of argon in the tank?

4. (4 points, 2 per part) Air is expanded in an adiabatic nozzle during apolytropic process with n = 1.3. The air enters the nozzle at 700 kPa and 100 ^{o}C with a velocity of 30 m/s, and exits at a pressure of 200 kPa. Calculate a) the air temperature and b) velocity at the nozzle exit.

5. (6 points, 2 per part) A container filled with 45 kg liquid water at 95 ^{o}C is placed in a 90-m^3 room initially at 12 ^{o}C. Assuming constant specific heat values for air and water, and a sealed and insulated room, find:
    a. the equilibrium temperature
    b. the amount of heat transferred between the water and room air
    c. the generated entropy in the universe.

6. (3 points) Liquid water enters a 25 kw pump at 100 kPa at a rate of 5 kg/s. What is the highest possible pressure at the pump outlet, neglecting kinetic and potential energy changes and assuming the density of water is 1,000 kg/m^3?

7. (3 points) Steam at 3 MPa and 400 ^{o}C is expanded to 30 kPa in an adiabatic turbine with an isentropic efficiency of 92 percent. If the mass flow rate os steam is 2 kg/s, what is the <u>actual</u> power output?

8. (4 points, 2 per part) R-134a is throttled from 900 kPa amd 35 ^{o}C to 200 kPa. Heat is lost at a rate of 0.8 kJ/kg to the surroundings at 25 ^{o}C. Find:
    a. the exit temperature of the R-134a
    b. the entropy generated in the surroundings

9. (3 points) Air in a large building is kept warm by heating it as it passes through a well-insulated heat exchanger. Saturated water vapor enters the exchanger at 35 ^oC and a flow rate of 10,000 kg/hr, and leaves as a liquid at 32 ^oC. Air at 1-atm enters the exchanger at 20 ^oC and leaves at 30 ^oC. What is the rate of entropy generation associated with this process?

10. (4 points, 2 per part) Liquid water at 200 kPa and 20 ^oC is heated in a chamber by mixing it with superheated steam entering the mixer at 200 kPa and 150 ^oC. The mass flow rate of the liquid water is 2.5 kg/s and the chamber is estimated to lose 1200 kJ/min heat to the surroundings at 25 ^oC. The mixture leaves the mixing chamber at 200 kPa and 60 ^oC. Determine:
    a. the mass flow rate of superheated steam
    b. the rate of entropy generation during mixing

11. (3 points) One kg air is in a piston-cylinder device that can only exchange heat with a reservoir at 300K. Initially the air is 100 kPa and 27 ^oC. It is claimed that the air can be compressed to a final state of 250 kPa and 27 ^oC. Does this claim satisfy the <u>second law</u>?

12. (4 points, 2 per part) Air is compressed in a steady-state compressor from 100 kPa and 17 ^oC to 700 kPa. The mass flow rate of air is 5 kg/min. Determine the minimum power input if the process is:
    a. Adiabatic
    b. Isothermal