Student Code Number:____________________

Ph.D. Qualifying Exam

Thermodynamics

Fall 2011

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Directions: Open Book (only one book allowed) and closed notes

Answer all six questions

All questions have equal weight

Time: 3.0 hours

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- Take any required property from your book, approximate values if necessary
- If you make any assumptions to reach a solution, state it clearly

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Question # 1

a) Refrigerant 134a is compressed polytropically (pv^n=constant) from an initial state T_1=263K & P_1= 200 kPa to a final state T_2= 323K & P_2= 1000 kPa. Determine the (i) work transfer for the process in kJ/kg (ii) heat transfer for the process in kJ/kg and (iii) sketch the process on a p-v and T-v diagrams.

b) Consider an isentropic compression of Helium from an initial state T_1=200K & P_1= 2bar to a final state P_2= 14bar. Assuming Helium is an ideal, determine the (i) work transfer for the process in kJ/kg (ii) heat transfer for the process in kJ/kg and (iii) sketch the process on a p-v and T-v diagrams.

Question # 2

a) A steam turbine inlet is at 1200 kPa, 500^{o}C. The exit is at 200 kPa. What is the lowest possible exit temperature? If no exact value take nearest best value, a T-S diagram can help your answer!

b) Steam enters a turbine at 3 MPa, 450°C, expands in a reversible adiabatic process and exhausts at 10 kPa. Changes in kinetic and potential energies between the inlet and the exit of the turbine are small. The power output of the turbine is 800 kW. (i) What is the mass flow rate of steam through the turbine? (ii) Sketch the process on the T-S and P-V diagrams

Question # 3

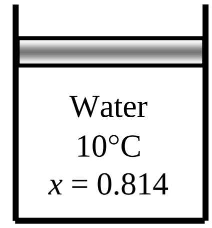
A well-insulated heat exchanger is to heat water (c_p = 4.18 kJ/kg · °C) from 25 to 60°C at a rate of 0.50 kg/s. The heating is to be accomplished by geothermal water (c_p = 4.31 kJ/kg · °C) available at 140°C at a mass flow rate of 0.75 kg/s. Determine (a) the rate of heat transfer and (b) the rate of entropy generation in the heat exchanger.

Question # 4

You have water at 10 ^{0}C and 81.4 % quality in a piston assembly. The water is compressed adiabatically and through a reversible process to 3 MPa of pressure.

Assumptions: **1** kinetic and potential energy changes are zero. **2** only work interaction is boundary work. **3** The compression or expansion process is quasi-equilibrium.

a) Determine the boundary work required to achieve this process
b) Plot this process on a T-s diagram
c) After the compression, let's assume we cool it down at constant pressure to a saturated vapor. What is the final temperature ?



Question # 5

3 kg of saturated liquid and vapor mixture of R-134a is in a closed container and in contact with a thermal reservoir at -5 ^{0}C. The R-134a is at 160 kPa. 180 kJ of Heat is transferred to the refrigerant from the thermal reservoir, and the liquid is vaporized and leaves as a saturated vapor at the same pressure.

Assumption: Isothermal, internally reversible process.

a) What is the quality *(x)* of the R-134 prior to the heat transfer
b) Find the entropy change of the refrigerant
c) Find the entropy change of the thermal reservoir

Question # 6

You have a round solid mass which is initially at a temperature of 300 K. The mass has a specific heat defined as follows: $C_v = C_p = T^{1.2} + 3$.

a) Find the **exact** entropy change of this mass if the temperature increases to 1000 K
b) How much heat (kJ/kg) would the mass have to give up through heat transfer to return to the original entropy? (assume that the contact temperature during heat transfer is at 1000K, and that the process is reversible)
c) What would be the change in internal energy of the solid mass during this heat transfer.