THERMODYNAMICS QUALIFYING EXAM

January 2013

OPEN BOOK (only one book allowed) & CLOSED NOTES

Answer all four questions

All questions have equal weight

TIME: 3.0 hrs

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• Take any required property from your book, approximate values if necessary.
• If you make any assumption to reach a solution state it clearly
**Question # 1**

a) A piston/cylinder setup contains air at 100 kPa, 400 K, which is compressed to a final pressure of 1000 kPa. Consider two different processes:

(i) A reversible adiabatic process and show the process in a T-S diagram and find the final temperature and the specific work (KJ/kg) for the process.

(ii) A reversible isothermal process, and show the process in a T-S diagram, and find the final temperature and the specific (KJ/kg) work for the process.

b) A steam turbine inlet is at 1200 kPa, 500°C. The exit is at 200 kPa. What is the lowest possible exit temperature? Show the process in a T-S diagram

c) 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 diagram
Question # 2

a) A piston–cylinder device contains 0.024 kg of air in a volume of 0.02 m³ initially at 0.1 MPa. The air is first compressed at constant volume to a pressure of 0.42 MPa, then it is further compressed at constant pressure, and finally it is expanded isothermally to the initial state.

i) Sketch the process on a P-V and T-S diagrams,

ii) Determine the change in entropy for each process, and

iii) Determine the total change in entropy for all process.

b) Prove that the two relations for entropy change of ideal gases under the constant-
specific-heat assumption are equivalent and the same.

\[ s_2 - s_1 = c_v \ln \frac{T_2}{T_1} + R \ln \frac{v_2}{v_1} \]

\[ s_2 - s_1 = c_p \ln \frac{T_2}{T_1} - R \ln \frac{P_2}{P_1} \]
**Question # 3**

An air-water vapor mixture enters an air conditioning unit at 110kPa, 30 C, with a relative humidity of 50%. The mass flow rate of air entering the unit is 1 kg/s. The air-vapor mixture leaves the unit at 105kPa and 10C. Determine the rate of heat transfer for this process.
Question # 4
A new stratified charged engine is capable of operating with octane (C₈H₁₈) and an average it is burned with 200% theoretical air. To save the catalytic converter from the problems of dissolved corrosive gases in the exhaust system, to what temperature must the exhaust be maintained so that liquid does not collect in the exhaust system?