

January 29, 2008

ASSIGNED NUMBER _____

SECTION _____

INSTRUCTOR _____

EXAMINATION

MECHANICAL AND AEROSPACE ENGINEERING

2008 PhD. QUALIFYING EXAM

Department of Mechanical & Aerospace Engineering
Ph.D. Qualifying Exam—January 2008

Thermodynamics
(2 hours; Closed book)

1. From the Tds equations, derive an equation that may be used to calculate the entropy change of an ideal gas in terms of the initial and final temperatures and pressures. Assume constant specific heats. What assumptions were required to derive the Tds equations? What assumptions must be satisfied for the derived equation? Explain your answer in detail.
2. A reversible and adiabatic compressor raises the pressure of air by factor of 20:1. The inlet temperature is 300 K. Determine the power input required if the flow rate is 10 kg/s. The specific heat ratio of air is 1.4.
3. A rigid tank of volume 2 m^3 contains hydrogen initially at $35 \text{ }^\circ\text{C}$ and 215 kPa. Heat is transferred to the tank from a reservoir at $300 \text{ }^\circ\text{C}$ until the hydrogen reaches $160 \text{ }^\circ\text{C}$. The temperature at the system boundary where heat transfer is occurring is $300 \text{ }^\circ\text{C}$. Determine the change in entropy of the hydrogen in kJ/K and the entropy produced by the process in kJ/K. Use constant specific heats at 300 K.
4. A 1 cm diameter air bubble rises in the ocean at a location where the pressure is 10 atm. Determine the boundary work done by the bubble on the water and the entropy change of the air as it rises to the surface assuming a) an isothermal process and b) a reversible and adiabatic process. Assume the water temperature is 300 K at all depths and the initial air temperature is also 300 K. The pressure at the surface is 1 atm.
5. A piston/cylinder system contains 2 kg of H_2O at $50 \text{ }^\circ\text{C}$ and 1 atm. Heat transfer occurs to the system and the system undergoes a constant pressure process. The final temperature is $200 \text{ }^\circ\text{C}$.
 - a) draw the process on a T-v and P-v diagram.
 - b) draw how the process would look on a T-v diagram if the pressure was supercritical and the final temperature was $800 \text{ }^\circ\text{C}$, include the vapor dome.
 - c) calculate the heat transfer.
 - d) calculate the total entropy generation if the heat comes from a source at $1000 \text{ }^\circ\text{C}$.