Ph.D. Qualifying Examination

Thermodynamics

Spring 2011

Logistics Notes:

- Time allowed: 2 hours.
- Exam is open-book (one book) and open-notes (one notebook)
- State your assumptions, methods, and procedures. Show your work on blank exam sheets provided by the proctor.
- Calculators are allowed.
- Laptops and cell phones are not allowed.

PROBLEM 1 (60 percent)

A steady flow compressor is used to compress 2 kg/s of air to an exit pressure of 350 kPa. The air enters the compressor at 27degrees Celsius and 100 kPa (the temperature and pressure of the environment). The power input required for the compression is 918 kW, and the magnitude of the heat transfer rate from the compressor to the environment is 10 percent of the magnitude of the power input. Determine:

a. the temperature of the air at the exit of the compressor
b. the reversible power, the reversible useful power, and the irreversibility rate associated with the actual compressor

Assuming that the inlet and exit conditions were unchanged but that the compressor was well-insulated to eliminate the heat transfer, answer the following questions and justify your responses.

c. Would the magnitude of the power input for the adiabatic compressor be higher, lower, or the same as that for the actual compressor?
d. Would the irreversibility rate for the adiabatic compressor be higher, lower, or the same as that for the actual compressor?
e. Would the magnitude of the reversible power associated with the adiabatic compressor be higher, lower, or the same as that associated with the actual compressor?

PROBLEM 2 (40 percent)

A rigid, 20-m^3 outdoor storage tank containing R-134a has 20 percent of its volume occupied by liquid at 500 kPa. Heat from the sun adds 10^6 kJ of energy to the R-134a. Determine the mass of the refrigerant in the tank, the original temperature, final temperature, final pressure, and final quality of the refrigerant.