Code Number :.....

THERMODYNAMICS QUALIFYING EXAM

August 2005

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**

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Question # 1

A rigid, well-insulated tank of volume 0.5 m^3 is initially evacuated. At time t=0, air from the surroundings at 1bar 21°C begins to flow into the tank. An electric resistor transfers energy to the air in the tank at a constant rate of 100 W for 500 seconds, after which time the pressure in the tank is 1 bar.

Neglect kinetic and potential energy effect in your solution. Model the air as ideal gas

What is the temperature of the air in the tank, in °C, at the final time?

Question # 2

Steam enters a horizontal 15-cm-diameter pipe as a saturated vapor at 5 bar with a velocity of 10 m/s and exits at 4.5 bar with a quality of 95%. Heat transfer from the pipe to the surroundings at 300 K takes place at an average outer surface temperature of 400 K. For operation at steady state, determine

(i) the velocity at the exit, in m/s.

(ii) the rate of heat transfer from the pipe, in kW.

(iii) the rate of entropy production, m kW/K, for a control volume comprising only the pipe and its contents.

(iv) the rate of entropy production, m kW/K, for an enlarged control volume that includes the pipe and enough of its immediate surroundings so that heat transfer from the control volume occurs at 300 K.

Question # 3

(a) An evacuated tank of 0.5 m^3 volume is connected by a closed valve to a pressurized bottle of 0.01m^3 volume containing saturated liquid ammonia at 293 Kelvin. The valve is then opened and the ammonia flows in to the tank and the final temperature is 293 Kelvin. What is the heat transfer to or from the ammonia.

(b) An air compressor, a steam turbine and an electric generator are set on one shaft. The steam turbine drives the compressor on one end and the generator on the other end. The compressor compresses 10 kg/s of air from 98 kPa and 295 K to 1 MPa and 620 K. 25 kg/s steam expands in the turbine from 12.5 MPa and 500^0 C to 10 kPa and a quality of 0.92. Assuming the flow process both in the compressor and turbine is adiabatic, determine the net power delivered to the generator.

Question # 4

a) Consider a gas that is compressed from initial pressure and temperature p_1 & T_1 to final p_2 & T_2 conditions. The compression can be achieved by three compressors, where in one compressor the process is isothermal, in the second isentropic and in the third adiabatic. If R is the gas constant, C_p the specific heat at constant pressure and C_v the specific heat at constant volume, develop an expression for the change in entropy of the compression process when using each type of compressor. Also sketch all three compressions on one T-S (Temperature vs. Entropy) chart.

b) In a laboratory experiment on air flow in a duct, one student group measured the pressure, temperature, and velocity in the duct as 0.95 bar, 67°C, 75 m/s at a location known as **Location A**. At another location known as **Location B** the respective values were found to be 0.8 bar, 22°C, 310 m/s. The group neglected to note the direction of the flow. **Using some or all of the above measured data and any air property from your book, determine the direction of flow [A to B or B to A] by substantiating your answers with numerical values.**