Code Number :.....

THERMODYNAMICS QUALIFYING EXAM

January 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**

Question # 1

The rigid tank has a volume of 0,06 m^3 and initially contains a two-phase liquid-vapor mixture of H_2O at a pressure of 15 bar and a quality of 20%. As the tank contents are heated, a pressure-regulating valve keeps the pressure constant in the tank by allowing saturated vapor to escape. Neglecting kinetic and potential energy effects

(a) determine the total mass in the tank, in kg, and the amount of heat transfer, in kJ, if heating continues until the final quality is x = 0.5.

(b) plot the total mass in the tank, in kg, and the amount of heat transfer, in kJ, versus the final quality x ranging from 0.2 to 1.0.

Question # 2

An insulated cylinder is initially divided into halves by a frictionless, thermally conducting piston. On one side of the piston is 1 m^3 of a gas at 300 K, 2 bar. On the other side is 1 m^3 of the same gas at 300 K, 1 bar. The piston is released and equilibrium is attained, with the piston experiencing no change of state. Employing the ideal gas model for the gas, determine

(i) the final temperature, in K.

(ii) the final pressure, in bar.

(iii) the amount of entropy produced, in kJ/kg.

Question # 3

(a) An ideal gas is contained in a rigid tank of volume V initially at P_1 and T_1. Heat is supplied to the contents until the pressure P_2. However, a relief valve allows gas to escape so that the temperature remains constant. Derive an expression for the heat transfer in terms of V P_1 and P_2.

(b) A volume of 0.36 m^3 of air at 1.03 bars and 15^0 C is compressed isentropically to 10 bars (state 2). It is then cooled at constant pressure to its original temperature (state 3). Finally, it expands isothermally to the original pressure (state 1). Determine the heat and work interactions for (i) process 1-2 and (ii) process 2-3 and (iii) the net work for the cycle, all values in kilojoules.

Question # 4

(a) Nitrogen is compressed from 80kPa and 27^0C to 480kPa by a 10kW compressor. Determine the mass flow rate of nitrogen through the compressor for the following cases:

(i) Isentropic compression

(ii) Polytropic compression with n=1.3

(iii) Isothermal compression

(iv) Ideal two-stage polytropic compression with n=1.3

(b) Hot water at 70^0C and a rate of 3.6kg/s and cold water at 20^0C enter and adiabatic mixing chamber. The mixture leaves the chamber at 42^0C. Determine (i) the mass flow rate of the cold water and (ii) the entropy change as a result of the mixing