J.G.
OK

CARLETON UNIVERSITY

FINAL
EXAMINATION
April 20, 2005

DURATION: 3 HOURS No. of Students: 120

Department: **Mechanical & Aerospace Engineering**
Course: **MAAE 2400 Thermodynamics and Heat Transfer**
Instructor: **Associate Prof. T. Kaya**

AUTHORIZED MEMORANDA
Open book, Open Notes, Calculators are permitted.

Students **MUST** count the number of pages in this examination question paper **before** beginning to write, and report any discrepancy immediately to a proctor. This question paper has **2** pages. This examination question paper **MAY** be taken from the examination room.

Important Notes:

a) There are five (5) questions. Attempt all the questions.
b) Questions have the same values as indicated.

QUESTION 1 (20 POINTS) Consider an ideal vapour-compression refrigeration cycle, with ammonia as the working fluid. This cycle has an evaporator temperature of -20°C and a condenser pressure of 12 bar. Saturated vapour enters the compressor and saturated liquid exits the condenser. The mass flow rate is 3kg/min.

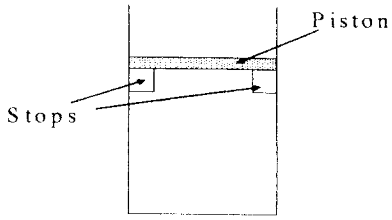
a) Determine the coefficient of performance.
b) Determine the refrigerating capacity in W.
c) Show the process schematically in a temperature-entropy (T, s) diagram. Please indicate clearly each state and the corresponding region on the diagram.

QUESTION 2 (20 POINTS) 5 kg saturated liquid-vapour mixture of water is contained in a piston-cylinder device at 100 kPa. Initially, 2 kg of water is in the liquid phase and 3 kg is in the vapour phase. The piston is resting on a set of stops as shown in the figure below. Heat is now transferred to this system. The piston starts moving when the pressure reaches at 150 kPa. Heat transfer continues until the total volume increases by 20 percent.

a) Determine the initial and final temperatures.
b) Determine the work done during the process.
c) Determine the total heat transferred to the system during the process.

3 6.
TK

d) Show the process schematically in a pressure-specific volume (p-v) diagram. Please indicate clearly each state and the corresponding region on the diagram.



QUESTION 3 (20 POINTS) In an ideal air-standard Bryton cycle, the rate of heat addition is given as 3.4×10^9 Btu/h. The pressure ratio for this cycle is 14. The minimum and maximum temperatures are 520°R and 3000°R, respectively. Determine,

a) the thermal efficiency of the cycle,
b) the mass flow rate of air in lb/h,
c) the net power produced by the cycle in Btu/h.

Note: This is an ideal air-standard Bryton cycle, the solutions with constant specific heats are not accepted.

QUESTION 4 (20 POINTS) Two insulated tanks are connected by an insulated valve. Tank 1 initially contains 1 kg of air at 50°C, 1 bar. Tank 2 contains 2 kg of air at 25°C, 2 bar. The valve is opened and two quantities of air are allowed to mix until equilibrium is attained. Air behaves as an ideal gas with constant specific heats. Determine,

a) the final temperature,
b) the final pressure,
c) the amount of entropy produced.

QUESTION 5 (20 POINTS) The hot gases in a furnace separated from the ambient air by two separate layers of brick adjacent to each other with 0.15 m thickness, each. The first brick layer next to the hot gases has a thermal conductivity of 2.5 W/mK. The second layer next to the ambient air has a thermal conductivity of 1.2 W/mK and a surface emissivity of 0.8. The ambient air and the surrounding room wall temperatures are 25°C. Free convection heat transfer coefficient between the second layer of brick and ambient air is 20 W/m^2K. Under steady conditions, the outer surface temperature of the second brick layer is measured as 100°C.

a) Determine the surface temperature of the first brick layer next to the hot gases.
b) Determine the total heat flux transferred from the furnace to ambient.
c) Show schematically the temperature distribution from the furnace interior wall to the outside air and indicate the corresponding temperature values on your drawing.