GEORGIA INSTITUTE OF TECHNOLOGY

The George W. Woodruff
School of Mechanical Engineering

Ph.D. Qualifiers Exam - Spring Semester 2003

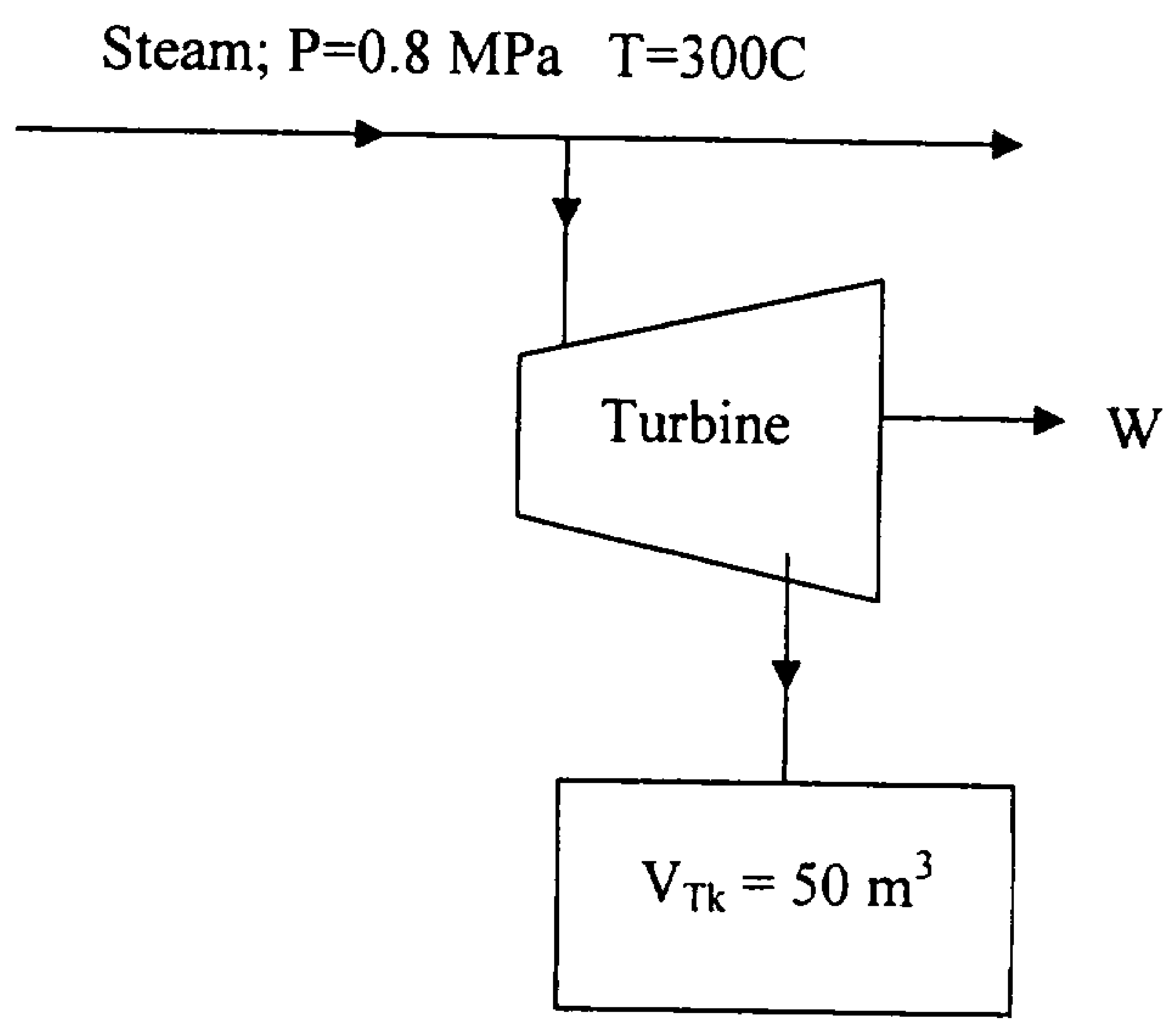
Thermodynamics
EXAM AREA

Assigned Number **(DO NOT SIGN YOUR NAME)**

- **Please sign your name on the back of this page—**

Problem # 1

Consider the turbine and tank device shown below. Steam flows in a steam line at 0.8 MPa, 300 C. From this steam line, steam flows through a steam turbine. The steam exhausts into a large chamber having a volume of 50 m^3. Initially, this chamber is evacuated. The turbine can operate until the pressure in the chamber reached 0.8 MPa. At this point the steam temperature in the tank is 280 C. Assume the entire process to be adiabatic. Determine the work done by the turbine during this process.



Problem # 2

A cylindrical container (density = 60 lbm/cubic ft, heat capacity = 1 Btu/lbm F, thermal conductivity = 0.5 Btu/sq-ft F) is six inches high and two inches in (inside) diameter. The cylinder's thickness is 1/8 inch. It contains 4 inches of water at 80 F. The container sits atop a surface having a thermal conductivity of 0.00001 Btu/sq-ft F.

How much ice must be added to this container to cool the water to 50 F?

Is this process possible?

If so, what is the irreversibility ?

State ALL of your assumptions and discuss the strong points and weak points of your approach to the problem.

Problem # 3

The schematic of a combined power cycle is shown in the figure. In this cycle a gas turbine (Brayton) cycle tops a steam turbine (Rankine) cycle. The heat exchanger functions as the evaporator for the Rankine cycle. Both portions of the combined cycle are assumed to be ideal. The Brayton cycle has a pressure ratio of 14, receives 10 kg/s of atmospheric air at 300 K, and heats the air to 1600 K in its combustion chamber. The combustion gases leave the boiler at 435 K temperature. The steam at inlet to the steam turbine is at 400°C temperature and 12 MPa pressure, and it leaves the turbine at a pressure of 15 kPa.

a) Schematically draw the air and steam processes on a T-s diagram
b) Calculate the steam mass flow rate
c) Calculate the net power output of the combined cycle
d) Calculate the thermal efficiency of the combined cycle

Assume constant specific heats for air, at room temperature.
Note that isentropic, ideal gas processes can be represented with
$Pv^k = const., \quad k = C_p / C_v$