GEORGIA INSTITUTE OF TECHNOLOGY

The George W. Woodruff
School of Mechanical Engineering

Ph.D. Qualifiers Exam - Fall Semester 2003

Thermodynamics
EXAM AREA

Assigned Number (DO NOT SIGN YOUR NAME)

- Answer **three** of the four questions
- Please sign your **name** on the back of this page —

Problem 1.

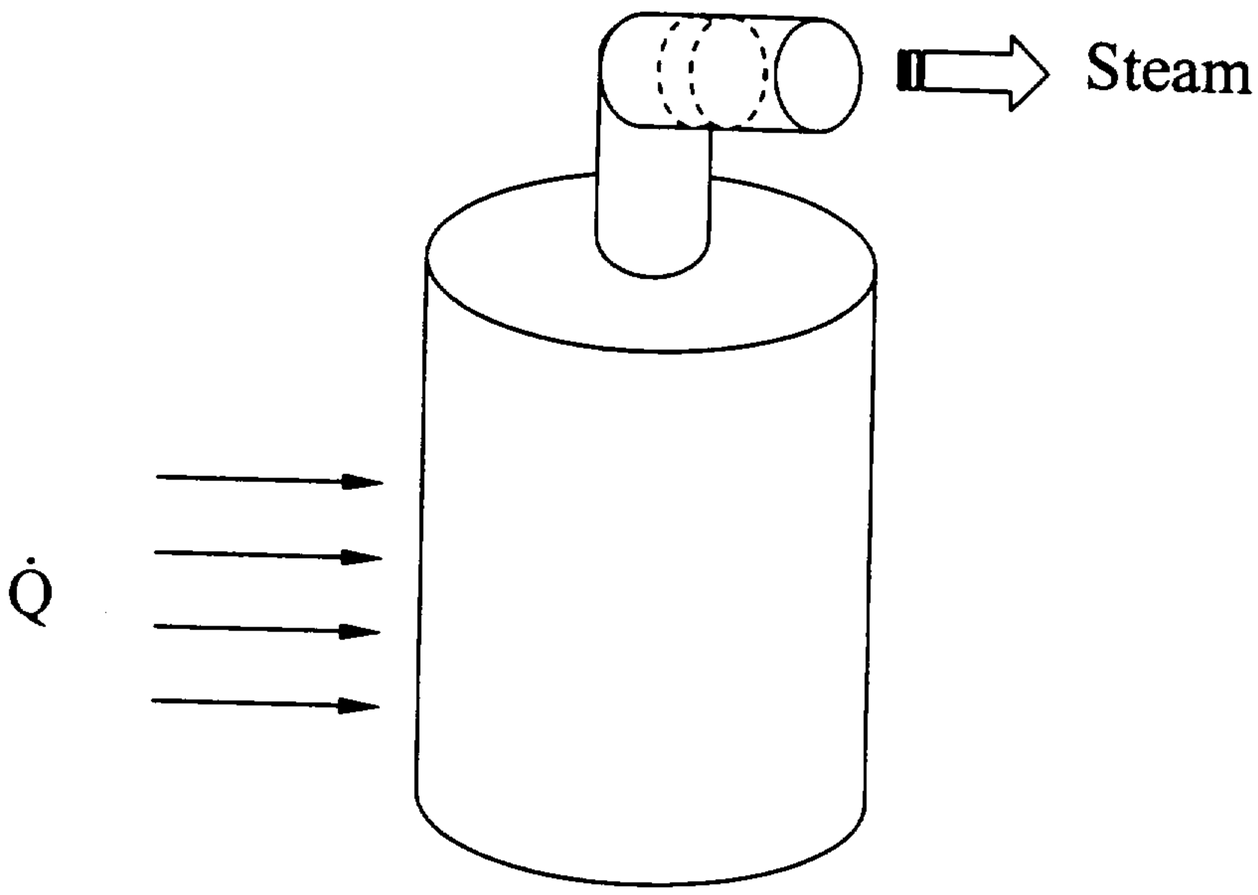
A boiler tank with a volume of 50 liters is designed to generate saturated steam at a pressure of 2 bar. The boiler is partially filled with water, and is heated to the operational pressure. The boiler contains 3.2 kg of saturated water-steam mixture when the operational pressure is first reached. During the following 30 minutes, the boiler is heated at a steady rate, generating saturated steam at a constant rate of 0.050 kg/min.

Find:

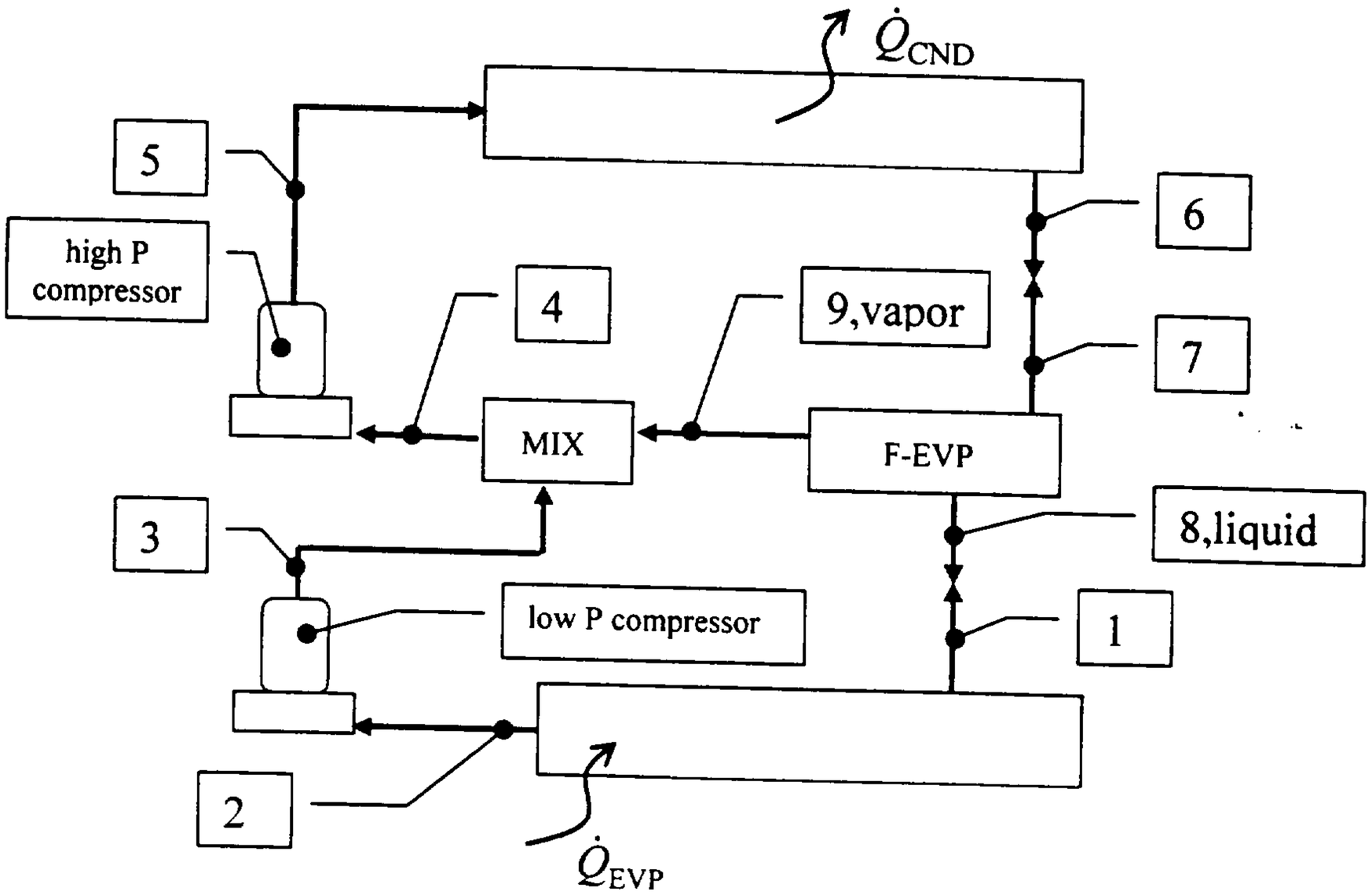
(1) The liquid water and steam masses in the boiler when the operational pressure is first reached.

(2) The total heat transferred to the boiler during the 30-minute operation.

(3) The heat transfer rate at 5 minutes after the initiation of the operation.



Problem 2. Consider the vapor compression chiller using **R134A** with flash intercooler illustrated below:



Assume that the low-pressure stations 1 and 2 are at a uniform pressure of 2 bar and that the fluid at station 2 is a saturated vapor. Assume that the intermediate pressure stations 3, 4, 7, 8, and 9 are at a uniform pressure of 6 bar. Assume that the high-pressure stations 5 and 6 are at a uniform pressure of 10 bar and that the fluid at station 6 is a saturated liquid. The vapor at 3 is at 30 °C, and the vapor at 5 is at 50 °C.

The component labeled F-EVP is an adiabatic flash evaporator or intercooler. Essentially it is just a phase separator. All of the vapor that enters is routed out to the left, and all the liquid is routed through the bottom. The component labeled MIX is merely an adiabatic mixing vessel.

(1) Find the pressures and enthalpies of the fluid at **every** indicated station: Temperatures are only optional entries and are **not** required.

station	Temp °C	Pressure bar	Enthalpy kJ/kg
1			
2			
3			
4			
5			
6			
7			
8			
9			

(2) Assume the flow at station **6** is 1 kg/sec. Find the flows at station **8** _____ kg/sec and at station **9** _____ kg/sec.

(3) Also find the COP for heating _____ and that for cooling _____.

Problem 3.

1 kg of water vapor at 200 °C and 100 kPa is condensed to a saturated liquid at 99.63 °C in a constant pressure process by heat transfer to the surroundings at 25 °C.

(1) What is the net increase in the entropy of the water and the surroundings as a consequence of this process? Please draw the process on a suitably chosen thermodynamic property chart.

(2) How would your answer change if you could employ a Carnot cycle that receives heat from the water after it has reached 99.63 °C and rejects heat to the surroundings?

List all assumptions.