GEORGIA INSTITUTE OF TECHNOLOGY

The George W. Woodruff
School of Mechanical Engineering

Ph.D. Qualifiers Exam – Spring Semester 2015

THERMODYNAMICS

EXAM AREA

Assigned Number (DO NOT SIGN YOUR NAME)

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

QUESTION 1

A 10.0 kg block of ice has been sitting a good while in a freezer whose temperature is maintained at 5.0°C below freezing. The block is then placed in a closable Styrofoam cooler, which originally contains 10.0 liters of water initially at 90.0°C. Find the equilibrium temperature.

$c_{H_2O\_solid} = 2.1$ kJ/kg-°C
$c_{H_2O\_liquid} = 4.2$ kJ/kg-°C
$\Delta h_{fus} = 334$ kJ/kg

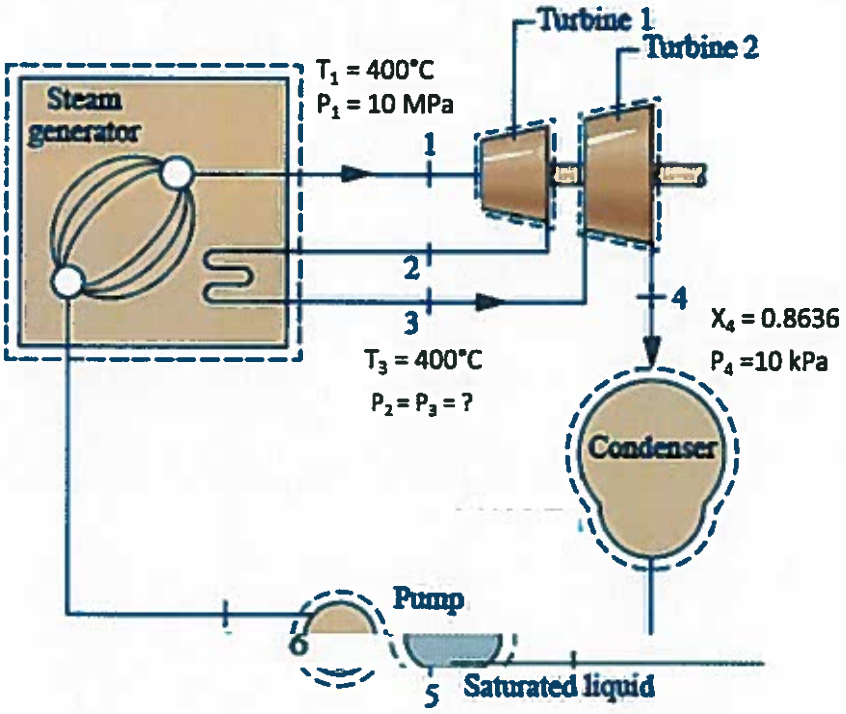
QUESTION 2

Consider a steam power plant operating the ideal reheat Rankine cycle. Steam enters the high-pressure turbine at 10 MPa and 400°C and is condensed in the condenser at a pressure of 10 kPa. The quality of the steam, x, at the exit of the low-pressure turbine is 0.8636. Condensate exits the condenser as saturated liquid. Assume the steam is reheated to the inlet temperature (400°C) of the high-pressure turbine.

a) Determine the pressure at which the steam should be reheated, in bar.

b) Determine the thermal efficiency of the cycle.

c) Sketch the processes on the T-s diagram.



QUESTION 3

Consider the filling of two empty air tanks from a supply line at P_0, T_0 with compressors, and then the subsequent mixing of those air tanks.

With the valve connecting the tanks closed (*i.e.*, valve 1 is closed), Tank 1 is filled to a pressure P_1 using a reversible isothermal compressor and Tank 2 is filled to a pressure P_2 using a reversible adiabatic compressor; Tank 2 is a piston cylinder assembly maintained at pressure P_2 during the filling process by a weight.

a) What is the change in specific entropy (Δs_{iso}) of air through the isothermal compressor?
b) What is the change in specific entropy (Δs_{adi}) of air through the adiabatic compressor?
c) What is the final temperature of Tank 1 and Tank 2?

With the valves connected to the compressors closed (*i.e.*, valve 2 and 3 are closed), consider the mixing process of Tank 1 at temperature T_1 and Tank 2 at temperature T_2 (*i.e.*, valve 1 is opened). Assume each tank has the same volume V and are thermally insulated during this second process. You may treat air as an ideal gas having constant specific heats (c_p and c_v).

d) What is the change in entropy (ΔS_{mix}) resulting from the mixing process?

Express your solutions in terms of the variables given in the problem statement and the air specific gas constant R.