Problem 1

A 10.0 kg block of ice has been sitting a while in a freezer whose temperature is maintained at 5.0 degrees below freezing. The block is then is placed in a Styrofoam chest, which originally contains 10.0 liters of warm water, initially at T_i .

Find the equilibrium temperature for:

a) $T_i = 90^{\circ}\text{C}$

b) $T_i = 75^{\circ}\text{C}$

You may assume:

$c_{ice} = 2.1 \frac{\text{kJ}}{\text{kg}-^{\circ}\text{C}}$ (specific heat of ice)

$c_{water} = 4.2 \frac{\text{kJ}}{\text{kg}-^{\circ}\text{C}}$ (specific heat of liquid water)

$\Delta h_{fus} = 334\ \text{kJ/kg}$ (heat of fusion of water)

$\rho_{water} = 1.0\ \text{kg/liter}$ (density of liquid water)

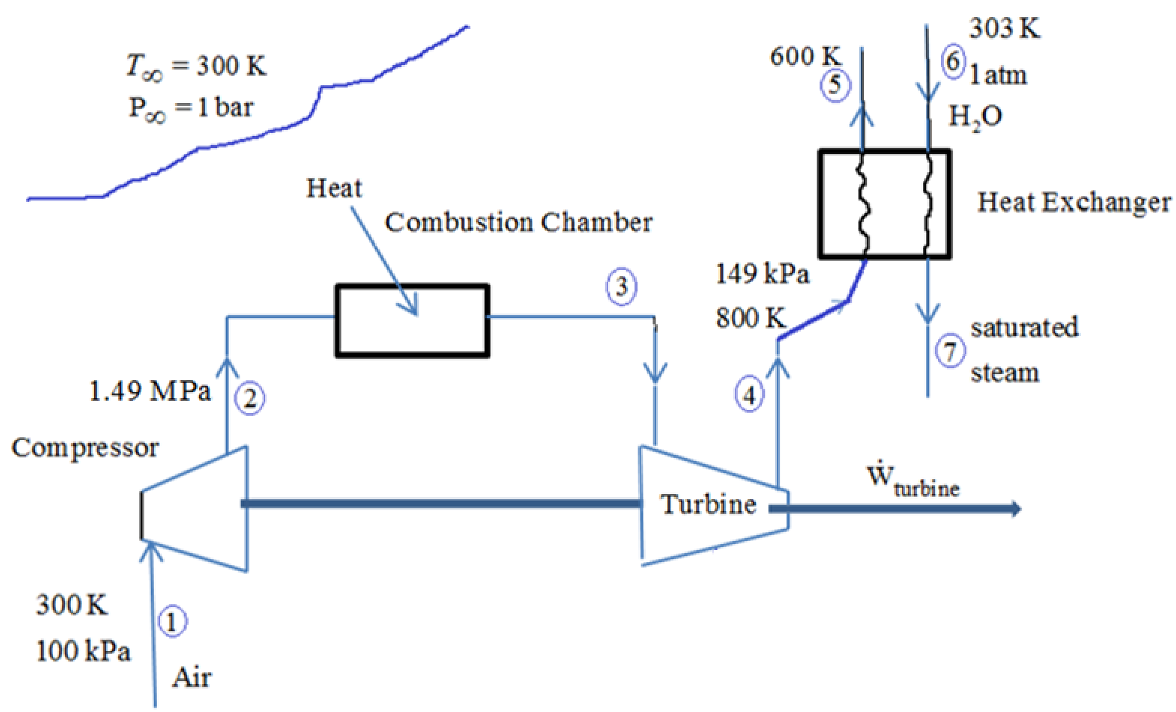
Problem 2

Consider the co-generation plant shown in the figure. Ambient air at 300 K temperature and 100 kPa pressure enters the compressor of the open Brayton cycle. The air is then pressurized to 1.49 MPa by the compressor. The air leaves the turbine at 800 K temperature and 149 kPa pressure, and from there it flows through a heat exchanger in which it causes the evaporation of atmospheric-pressure water. Water enters the heat exchanger at 303 K temperature and leaves as saturated steam. Air leaves the heat exchanger at 600 K. The pressure drops of both water and air streams in the heat exchanger are negligible. The isentropic efficiencies of the compressor and turbine are 0.85 and 1.0, respectively. The plant produces steam at the rate of 10 kg/s. The environment pressure and temperature are 1 bar and 300 K, respectively.

Determine:

a) the mass flow rate of air
b) the entropy generation rate and exergy destruction rate in the heat exchanger
c) the net power generation rate by the plant
d) the exergy destruction rate in the turbine

- Assume that the compressor, turbine and heat exchanger are all well insulated.
- Do NOT assume constant specific heats for air.



Problem 3

A solar hot water system is used to provide heating to a power generator, which uses R-134a as the working fluid, as shown in the figure below. Saturated liquid water enters the heat exchanger (boiler) at 150 °C with a flow rate of 6 liters/min and exits at 40 °C. R-134a enters the turbine as saturated vapor at 80 °C and is condensed to saturated liquid at 26 °C before entering the pump. Assume that the turbine and pump are both adiabatic and reversible. Cooling water at near ambient pressure enters the condenser at 20 °C and exits at 24 °C.

(a) Find the thermal efficiency of the power generation cycle.

(b) Find the work produced by the turbine per second.

(c) Find the mass flow rate of the cooling water.