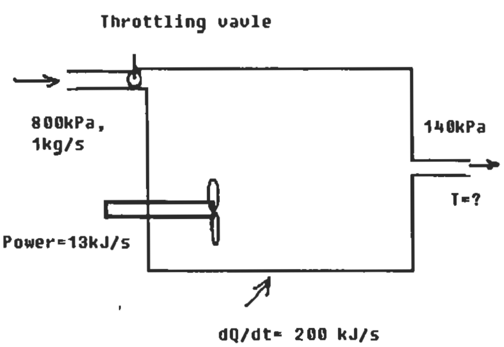
ME 105 Thermodynamics Sec 2 Midterm #1 Prof. J.-Y. Chen 3/9/04

4 Problems (100 points)

1) (20 points) Answer true or false for each statement (4 points each)

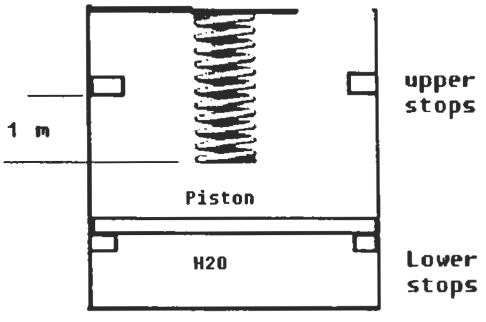
a) The compressibility of any substance is less than one.
b) Water cannot be vaporized at 20°C.
c) For a substance that expands on freezing, the substance cannot exist in solid phase when the temperature is above the triple point.
d) The relative error of using ideal gas law to compute the specific volume of saturated water vapor at 5MPa is less than 30%.
e) Assuming $h_e=h_{in}$ for a throttling process, the temperature at the exit of a throttling device is always lower than that at the inlet.

2) (25 points) Refrigerant-134a is throttled from the saturated liquid state at 800kPa into a rigid device and exits at 140 kPa. The mass flow rate of R-134a is 1kg/s and the heat transfer into the device occurs at a rate of 200 kJ/s and the power of the stirrer into the device is 13kJ/s. When the device reaches the steady state, determine the temperature of R-134a at the exit.



3) (40 points) A piston-cylinder device consists of two sets of stops and a linear spring with a spring constant of 100kN/m as shown in the sketch. Initially, the cylinder contains 1 kg of water at 100kPa with a volume of 1 m^3 and the frictionless piston sits on the top of the two lower stops. The area of piston is 1 m^2. Heat is transferred to the cylinder until the final pressure reaches 350kPa. The piston starts to move when the pressure reaches 200kPa. When the cylinder volume reaches 2 m^3, the piston starts to compress the spring. The total distance that the spring can be compressed is 1m.

a) Determine whether or not the piston hits the upper stops at the final state. (5 points)
b) Sketch the process on a P-V diagram (10 points)
c) Determine the amount of work done by the water during this process (10 points)
d) Determine the temperature at the final state (5 points)
e) Determine the amount of heat transferred to the cylinder during this process (10 points)



Continue on next page.

4) (15 points) Compressed air stored in a huge vessel at 300K and 500kPa is used for generation of power during emergency. Connected to the vessel through a valve is a turbine followed by a small initially evacuated tank with a volume of 1 m^3. When power is needed, the valve is opened and the tank fills with air until the pressure is 500kPa and the temperature of air in the tank is 250K. The filling process takes place adiabatically and kinetic and potential energy are negligible. Assuming the following: a) the state of air inside the huge vessel remains constant, b) the amount of mass stored within the turbine and the connecting piping is negligible, and c) air is an ideal gas with constant specific heats Cp=1.0 kJ/kg-K, Cv=0.713 kJ/kg-K, and gas constant R=0.287 kJ/kg-K, determine the amount of power developed by the turbine.