AREN 2110
Spring 2011

Homework #5: Due Friday, Feb. 25, 6 PM (35 points)

1. (2 points) It is possible to compress an ideal gas isothermally in an adiabatic piston-cylinder device? Explain.

2. (2 points) A room 4-m x 5-m x 6-m is to be heated by a baseboard electric resistance heater which can raise the room air temperature from 7 to 23 ^oC within 15 min. Assuming no heat losses from the room and atmospheric pressure of 100 kPa, what is the power requirement for the electric heater in kw?

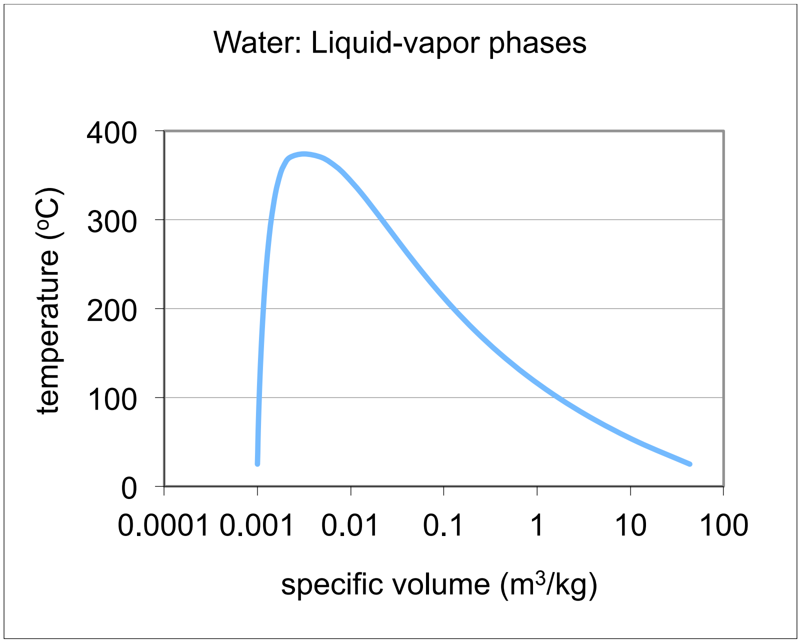
3. (2 points) A student living in a dormitory room with a volume of 144 m^3 turns on her 150-w fan before she leaves for classes on a warm day in the hopes of finding her room cool when she returns. She also closes all the windows and door to minimize heat gain from the outside. Assume the initial temperature of the room is 15 ^oC and the atmospheric pressure is 100 kPa. Assuming no heat gain from outside, what is the temperature of her room when she returns 10 hours later?

4. (2 points) Air is contained in a variable load piston cylinder device equipped with a paddle wheel. At the initial state, the air pressure is 500 kPa and temperature is 27 ^oC. The paddle wheel is then turned by an electric motor to provide 50 kJ/kg work to the air. During the process heat is transferred to maintain a constant temperature while the volume of the air in the cylinder triples. What is the required heat transfer for the process (kJ/kg)?

5. (2 points) Air with amass of 15-kg is heated from 25 to 77 C in a piston-cylinder device which maintains constant pressure of 300 kPa during the process. Heat loss through the cylinder wall is 60 kJ. The air is by an electric resistance heater. How much lectric energy must be supplied in kwh?

6. (3 points) A well-insulated rigid tank contains 3 kg saturated liquid water at 40 ^oC. The water is heated by a 500-w electric resistance heater.

    a. What is the temperature of the water after the heater has been on for 30 minutes?
    b. Compare a solution using the saturated water tables to one assuming that water is an ideal liquid with a specific heat of 4.18 kJ/kg-K.
    c. Draw the process on the T-v diagram on the next page.

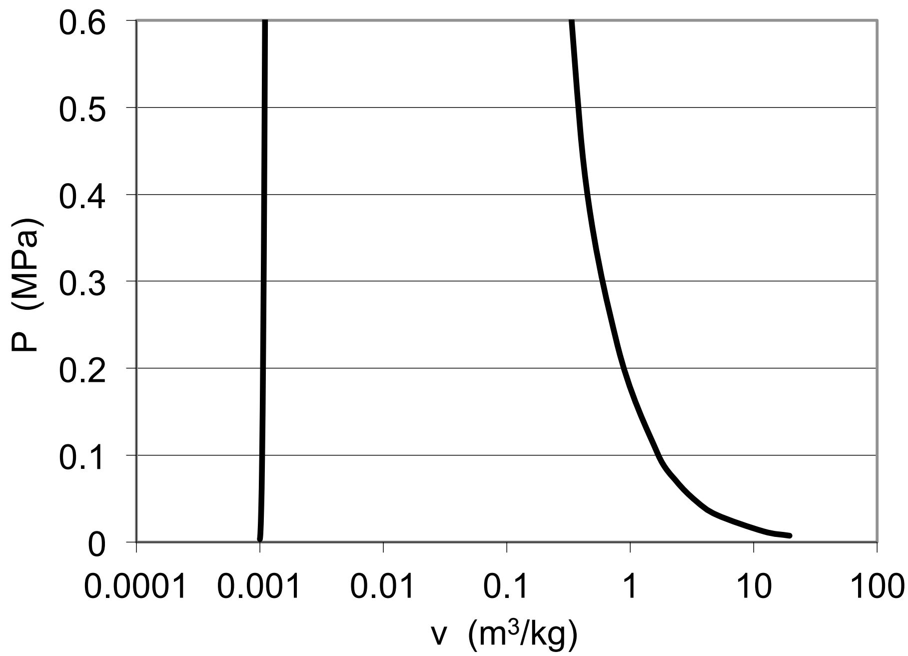


7. (2 points) A room containing 120 m^3 air at 100 kPa is to be maintained at 20 ^oC by heat transfer from a one metric ton (1000 kg) tank of water in the room. The room loses heat to the outside at an average rate of 8000 kJ/hr, averaged over 24 hours. What must the initial temperature of the water be at the beginning of a 24-hour cycle?

8. (5 points) A mass of 5 kg of saturated liquid-vapor water mixture is contained in a piston cylinder device where a pressure of 300 kPa is required to lift the piston. The initial pressure of the water is 125 kPa, and at the initial state, 2 kg of the water is saturated liquid. Heat is now transferred to the water until the volume increases by 20%.

    a. Find the initial and final temperatures of the water.
    b. What is the mass of liquid water when the piston starts to move?
    c. What is the work done in the process?
    d. What is the amount of heat that must be added?
    e. Draw the process on the P-v diagram (next page).

P-v diagram for water 7e.



9. (5 points) You have been hired to design a heating system for a swimming pool that is 2-m deep, 25-m long and 25-m wide. The heater must satisfy two criteria. First, it must supply enough heat to raise the temperature of the water in the outdoor pool from 20 to 30 ^{o}C in 2 hours. Second it must be able to maintain the pool at 30 ^{o}C. The average rate of net heat loss to the air is 960 w/m^2. Losses to the ground through the pool walls can be neglected. The efficiency of the heater is 80%. What is the heater size you would design for your client (kw).

7. (5 points) A piston cylinder contains 0.35-kg steam initially at 3.5 MPa and 250 ^{o}C. The steam loses heat to the surroundings and the piston moves down until it hits a set of stops. At this point, the steam has been condensed to saturated liquid. The cooling continues while the piston is resting on the stops until the water temperature is 200 ^{o}C. Determine:

   a. The final pressure and quality (if a mixture)
   b. The boundary work over the entire process sequence (kJ)
   c. The heat transferred when the piston first hits the stops (kJ)
   d. The total heat transfer over the entire process sequence (kJ)

12. (5 points) THERMODYNAMICS IN THE NEWS. Iceland gets about one-third of its electricity and almost all of its heating from geothermal sources. Using the article in the link, http://www.sciencecentric.com/news/11021810-magma-power-geothermal-energy.html, or other sources, comment on the advantages and disadvantages of geothermal sources for power generation and heating/cooling.