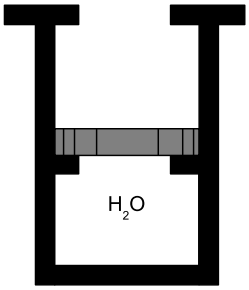
Middle East Technical University
Department of Chemical Engineering
ChE204 Thermodynamics I (Section 3)
2012-2013 Fall Semester

October 19, 2012

PROBLEM SET 3

Problems 5 and 6 are homework due October 30

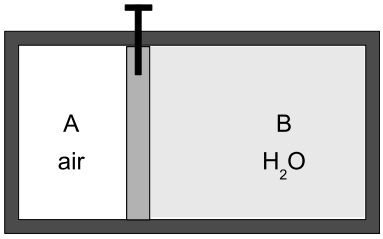
1) Consider the piston-cylinder arrangement indicated in the figure. The piston is frictionless and is free to travel between two sets of stops. When the piston is resting on the lower stops the enclosed volume is 0.4 m^3. When the piston encounters the upper stops the enclosed volume is 0.6 m^3. Initially the cylinder is filled with water at 0.1 MPa and a quality of 20 %. The water is then heated until it exists as saturated vapour. If the mass of the piston is such that 0.3 MPa is required to move it against atmospheric pressure, determine,



a. the final pressure in the cylinder.

b. the heat transfer and the work done during the process.

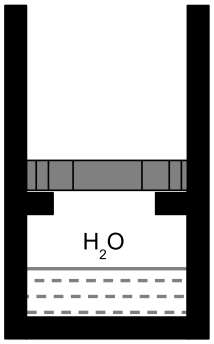
2) A closed cylinder with diathermal walls is divided into two rooms by a frictionless piston held in place by a pin. Room A has 10 L air at 100 kPa, 30°C, and room B has 300 L saturated water vapour at 30°C. The pin is pulled, releasing the piston, and both rooms come to equilibrium at 30°C. Considering the contents of A and B together as the system, determine the work done by the system and the heat transfer to the cylinder.



3) A rigid vessel is divided internally by a partition into two parts of 0.3 m^3 each. One part contains steam at 20 bar and 250°C, while the other part contains dry saturated steam at atmospheric pressure. The partition is punctured, and the two quantities of steam are allowed to mix until the tank contents are at uniform temperature and pressure. During this process the tank loses 390 kJ of heat. What are the final temperature and pressure?

4) Two kilograms of wet steam with a quality of 0.9 at 100 kPa is contained in a cylinder fitted with a movable, frictionless piston. This wet steam is now heated at constant pressure until the temperature reaches 300°C. Calculate Q, W, ΔU and ΔH considering the contents of the piston-cylinder device as the system. Show the process on P-V and P-T diagrams.

5) 5 kg of wet steam with a quality of 40% is contained in a piston-cylinder device at 100 kPa as shown in the figure. The piston, which is initially resting on a set of stops has a weight such that it moves when the pressure inside reaches 200 kPa. Heat is transferred to the contents of the cylinder until the volume doubles. Show the process on a P-V diagram and determine:



a) the final temperature,

b) mass of water in the liquid phase when the piston starts moving,

c) the work done by the water,

d) the heat transferred to the water.

6) A closed cylinder with a volume of 50 L contains a movable, frictionless piston which separates the cylinder into two portions. In one of these portions is nitrogen gas, whereas in the other is a two-phase mixture of 20 kg of water and water vapor. The cylinder walls and the piston itself are excellent conductors of heat.

Initially, with the temperature of the entire apparatus at 100°C, the piston divides the cylinder evenly into two equal portions. The whole unit is then heated to 120°C.

a. How far will the piston move (expressed as percent of total cylinder length) and in which direction?

b. How much heat will be transferred to the cylinder during this process? Neglect the heat capacity of the cylinder and the piston.

7) Water is brought to a boil in a pressure cooker at atmospheric pressure. The steam drives out all the air and the valve is then closed, i.e. when the valve is closed there exists only H_2O in the cooker. The cooker is then left on the stove until the pressure reaches 12 bar, at which time the steam is superheated.

a. Show this entire process on P-V and P-T diagrams, identifying *(i)* the point where boiling just begins, *(ii)* the point where the valve is closed, *(iii)* the point where the last of the liquid is vaporized and *(iv)* the final state.

b. If the volume of the pressure cooker is 14 L and there is 0.05 kg H_2O in the cooker when the valve is closed, what is the final pressure when the liquid phase disappears?

c. What is the final temperature?