Quiz 1

Problem 1 (50 points)

A large rigid vessel of unknown total volume is divided into two compartments by a partition: The first compartment of volume 0.5 m^3 initially contains saturated liquid-vapor mixture of water at 100 °C while the second compartment is evacuated. The water in the first compartment is heated while the partition is fixed (not allowed to move). In what follows, sketch all the processes on a $p - v$ and $T - v$ diagram.

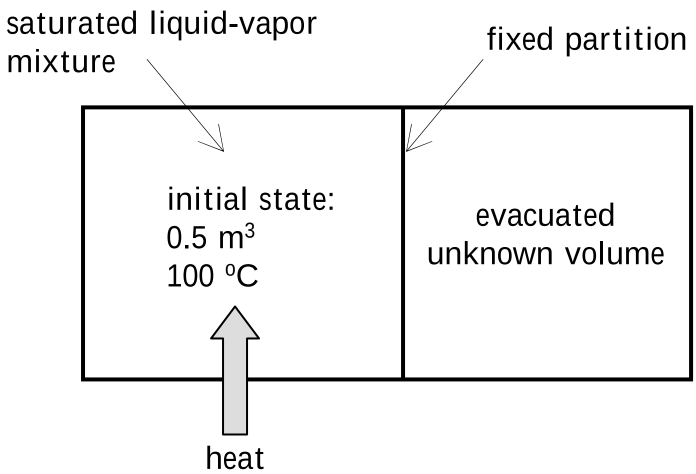

Figure 1: Schematic for problem 1.

(a) If at the end of the heating process, the final state of water is saturated liquid, what are the minimum and maximum possible values of the range of mass of the liquid water at the initial state? What is the corresponding range of the volume of liquid water at the initial state?
(b) If at the end of the heating process, the final state of water is saturated vapor, what are the minimum and maximum possible values of the range of mass of the liquid water at the initial state? What is the corresponding range of the volume of liquid water at the initial state?

If at the end of the heating process, the final state of water is compressed liquid water at 250 °C. At this point, the entire vessel is insulated and the partition separating the two compartments is removed allowing water to fill the entire vessel. At the end of this process, the water temperature dropped by 20 °C.
(c) What is the initial volume of the vacuum compartment?

Problem 2 (50 points)

Consider the piston-cylinder arrangement shown in the Figure. The cylinder contains 3.5 grams of air and the piston is tightly sealed so that air cannot escape to the environment. The piston mass is 1 kg and its diameter is 20 cm. Initially air inside the cylinder is in thermodynamic equilibrium and the piston is at an elevation of 10 cm relative to the bottom of the cylinder. Stops in the cylinder at an elevation of 15 cm relative to the cylinder bottom prevent the cylinder from upward motion beyond that elevation. 1 kJ of heat is slowly added via an electric resistance properly situated inside the bottom wall of the cylinder.

(a) What are the initial pressure and temperature?
(b) Determine the final pressure and temperature.
(c) Determine the work done by the gas during the process and the work done against atmosphere.
(d) Sketch the process on $T - v$ and $p - v$ diagrams.

Assume the following: The piston is frictionless, air may be modeled as an ideal gas, and except for heat addition via the electric resistance no other forms of heat transfer take place across the boundary. Neglect changes in potential energy and kinetic energy of the air inside the cylinder. The ideal gas constant for air is $R = 0.287$ kJ/kg °K. State any additional assumptions you make.

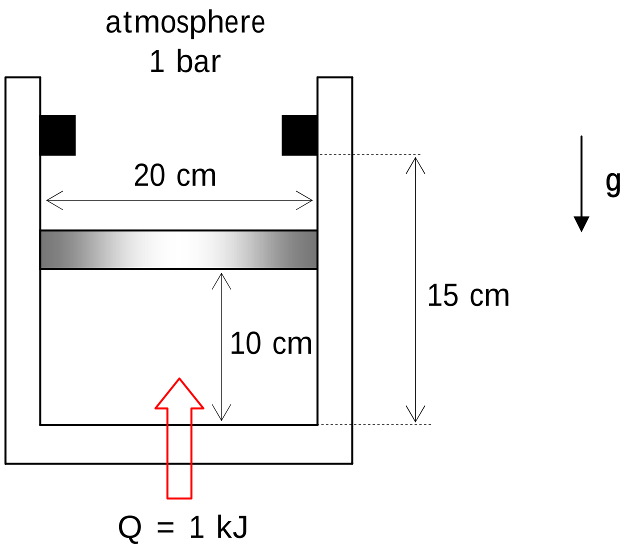

Figure 2: Schematic for problem 2.