SP01
One (1.0) kg of ice and 0.05 kg of water vapor exist in equilibrium in a closed, rigid vessel at a temperature $T_1 = -30^\circ\mathrm{C}$ and a pressure of $p_1 = 0.0381$ kPa (state1). The tank and the contents are then heated until a state on the liquid-vapor equilibrium line (saturation dome) is reached (state 2).

(a) What is the volume of the tank? (Hint: Use Table A-6)
(b) What is the initial pressure in bar?
(c) At the final condition, state 2, is the mixture a saturated liquid or a saturated vapor? (Hint: is the specific volume greater than or less than specific volume at the critical point?
(d) What is the final temperature at state 2?
(e) Sketch this process on p-T and p-v diagrams similar to those shown below (Chapter 3, Moran et al, 8th edition).

SP02
A throttling calorimeter shown below is used to determine the quality of a two-phase mixture of R-134a refrigerant that is flowing in a tube. The calorimeter operates by bleeding off a small fraction of the flow stream and throttling it to a lower pressure. The device is based upon the fact that over a wide range of temperatures and qualities, the two-phase refrigerant can be throttled to a superheated vapor state. In this case, it is possible to estimate the stream quality through the use of an energy balance and measurements of the temperature inside the tube and pressure exiting the throttling valve. Assuming that the two-phase refrigerant is at a temperature of 50 F and the stream is throttled to 4 psia, then do the following:

a. Determine the minimum and maximum possible exit temperatures from the throttle that will allow determination of quality.
b. What is the minimum quality that this device would be capable of measuring?
c. Use EES to plot the process line for the throttling process on a P-h diagram for an inlet quality of 0.9.
d. Use EES to plot the variation in quality as a function of measured exit temperature for the range determined in part a.

Your solution to this special problem must show the analysis, including basic equations and assumptions, and an EES printout that contains the equation worksheet, the parametric table, and plot.

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R-134a Throttling Calorimeter

**SP03**
A 4 liter pressure cooker has an operating pressure of 200 kPa when it is placed on a stove at a temperature of 1000°C. The environment temperature is 20°C. The heat loss from the cooker to the environment through the cooker wall and lid is 300 W. Initially, one half of the volume is filled with liquid and the other half with vapor. Neglect the kinetic energy and potential energy. Assume that the temperature and pressure are uniform throughout the cooker and heat is added at a fixed rate from the stove. If the pressure cooker runs out of liquid water after one hour, determine

a) The total mass of the steam entering the environment, in kg
b) The rate of heat transfer from the source, in kW (Answer: 1.4535 kW)