3.6 For H₂O, determine the specified property at the indicated state. Locate the state on a sketch of the T–v diagram.
   a. \( T = 140^\circ\text{C}, v = 0.5 \text{ m}^3/\text{kg}. \) Find \( T \), in °C.
   b. \( p = 30 \text{ MPa}, T = 100^\circ\text{C}. \) Find \( v \), in m³/kg.
   c. \( p = 10 \text{ MPa}, T = 485^\circ\text{C}. \) Find \( v \), in m³/kg.
   d. \( T = 80^\circ\text{C}, x = 0.75. \) Find \( p \), in bar, and \( v \), in m³/kg.

3.18 A closed, rigid tank contains a two-phase liquid–vapor mixture of Refrigerant 22 initially at \(-20^\circ\text{C}\) with a quality of 50.36%. Energy transfer by heat into the tank occurs until the refrigerant is at a final pressure of 6 bar. Determine the final temperature, in °C. If the final state is in the superheated vapor region, at what temperature, in °C, does the tank contain only saturated vapor?

3.51 Referring to Fig. P3.51, water contained in a piston–cylinder assembly, initially at 1.5 bar and a quality of 20%, is heated at constant pressure until the piston hits the stops. Heating then continues until the water is saturated vapor. Show the processes of the water in series on a sketch of the T–v diagram. For the overall process of the water, evaluate the work and heat transfer, each in kJ/kg. Kinetic and potential effects are negligible.
One (1.0) kg of ice and 0.05 kg of water vapor exist in equilibrium in a closed, rigid vessel at a temperature $T_1 = -30^\circ C$ and a pressure of $p_1 = 0.0381$ kPa (state 1). 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 and 9th edition).

Answer: (b) 0.000381 bar
2.45 As shown in Fig. P2.45, a gas contained within a piston–cylinder assembly, initially at a volume of 0.1 m³, undergoes a constant-pressure expansion at 2 bar to a final volume of 0.12 m³, while being slowly heated through the base. The change in internal energy of the gas is 0.25 kJ. The piston and cylinder walls are fabricated from heat-resistant material, and the piston moves smoothly in the cylinder. The local atmospheric pressure is 1 bar.

![Figure P 2.45](image)

**a.** For the gas as the system, evaluate work and heat transfer, each in kJ.
**b.** For the piston as the system, evaluate work and change in potential energy, each in kJ.

2.64 Figure P2.64 shows two power cycles, A and B, operating in series, with the energy transfer by heat into cycle B equal in magnitude to the energy transfer by heat from cycle A. All energy transfers are positive in the directions of the arrows. Determine an expression for the thermal efficiency of an overall cycle consisting of cycles A and B together in terms of their individual thermal efficiencies.

![Figure P 2.64](image)
SP-02
One kg of water-vapor mixture exists in an insulated piston-cylinder arrangement. Initially, the water is a mixture of saturated liquid and vapor at 100 kPa with a quality of 0.11. The paddle wheel is turned on, and the mass-less piston begins to lift as additional liquid is vaporized. At state 2, the piston hits the stops. The paddle-wheel continues to operate until the water is completely vaporized at state 3, the end of the process. \( V_3 = V_2 = 2.0 \times V_1 \). The ambient conditions are: \( T_0 = 300 \, K \), \( p_0 = 1 \, \text{bar} \).

a) draw this process on a p-v diagram.

b) compute the net work input for the entire process.
5

SP-03
A cooker with a volume of 0.5 L is boiling on a stove. The pressure in the cooker is 100 kPa. The environment temperature is 20°C. The heat loss from the cooker to the environment through the cooker wall and lid is 100 W. Initially one-half of the volume of the cooker is filled with liquid and the other half with vapor. Neglect 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 cooker runs out of liquid water after 1000 seconds, determine:

(a) Draw the system sketch and the control volume you use.
(b) The total mass of the steam entering the environment, in kg.
(c) The rate of heat transfer from the source (stove), in kW.

Answer: (b) 0.2395 kg
A rigid tank having a volume of 0.1 m$^3$ initially contains water as a two-phase liquid–vapor mixture at 1 bar and a quality of 1%. The water is heated in two stages:

Stage 1: Constant-volume heating until the pressure is 20 bar.

Stage 2: Continued heating while saturated water vapor is slowly withdrawn from the tank at a constant pressure of 20 bar. Heating ceases when all the water remaining in the tank is saturated vapor at 20 bar.

For the water, evaluate the heat transfer, in kJ, for each stage of heating. Ignore kinetic and potential energy effects.

The procedure to inflate a hot-air balloon requires a fan to move an initial amount of air into the balloon envelope followed by heat transfer from a propane burner to complete the inflation process. After a fan operates for 10 minutes with negligible heat transfer with the surroundings, the air in an initially deflated balloon achieves a temperature of 80°F and a volume of 49,100 ft$^3$. Next the propane burner provides heat transfer as air continues to flow into the balloon without use of the fan until the air in the balloon reaches a volume of 65,425 ft$^3$ and a temperature of 210°F. Air at 77°F and 14.7 lbf/in.$^2$ surrounds the balloon. The net rate of heat transfer is $7 \times 10^6$ Btu/h. Ignoring effects due to kinetic and potential energy, modeling the air as an ideal gas, and assuming the pressure of the air inside the balloon remains the same as that of the surrounding air, determine

a. the power required by the fan, in hp.
b. the time required for full inflation of the balloon, in min.
A rigid, poorly insulated tank with a volume of \( V = 1.0 \text{ m}^3 \) initially contains a saturated water vapor (quality of 1.0) at a pressure of 3 bars (300 kPa). The tank is connected to a supply line containing steam at a pressure of \( p_L = 10 \text{ bars} \) (1000 kPa) and a temperature of \( T_L = 500^\circ \text{C} \). The valve is opened and 2.0 kg of steam enters the rigid tank, after which the valve is closed. The pressure is measured after the valve is closed and it is found that \( p_2 = 5 \text{ bars} \) (500 kPa). Find

(a) the state of the fluid and the temperature \( T_2 \) (°C) at state 2
(b) the heat transfer \( Q_{CV} \) that occurs during the filling process. Is the heat transfer to or from the tank?

Answer: (a) 151.9 °C