Chapter 2 Properties of Pure Substances

Source: Cengel, Y.A., and Boles, M.A.,THERMODYNAMICS :An Engineering Approach, 5th Edition in SI unit,McGraw-Hill, 2006.

1. A well-sealed contains some water and air at atmospheric pressure. The tank is now heated, and the water starts boiling. Will the temperature in the tank remain constant during this boiling process? Why?

2. Complete the following table for WATER

	T, $^{\circ}$C	P, kPa	v, m3/kg	u, kJ/kg	Phase Description
a	50		4.16		
b		200			Sat.vap.
c	250	400			
d	110	600			
e	130			2,300	
f		600			Sat.liq.
g	400	500			
h	90	700			

3. A rigid tank with a volume of 2.5 m^3 contains 5 kg of saturated liquid-vapor mixture of water at 75°C. Now the water is slowly heated. Determine the temperature at which the liquid in the tank is completely vaporized. Also show the process on a T-v diagram with respect to saturation line.

4. A piston-cylinder device contains 0.1 m^3 of liquid water and 0.9 m^3 of water vapor in equilibrium at 800 kPa. Heat is transferred at constant pressure until the temperature reaches 350°C.
   (a) What is the initial temperature of the water?
   (b) Determine the total mass of the water.
   (c) Calculate the final volume.
   (d) Show the process on a P-v diagram with respect to saturation line.

5. A rigid tank contains 10 kg of air at 150 kPa and 20 $^{\circ}$C. More air is added to the tank until the pressure and temperature rise to 250 kPa and 30 $^{\circ}$C, respectively. Determine the amount of air added to the tank.

6. A 1 m^3 tank contains air 25 $^{\circ}$C 500 kPa is connected through a valve to another tank containing 5 kg of air at 200 kPa and 35 $^{\circ}$C. Now the valve is opened, and the entire system is allowed to reach thermal equilibrium with the

surroundings which are at 20 °C. Determine the volume of the second tank and the final equilibrium pressure of air. (answer:284.1 kPa)

7. What is the difference between saturated liquid and subcooled liquid?
8. What is the difference between saturated vapor and superheated vapor?
9. Is it true that water boils at higher temperature at higher pressure? Explain.
10. If the pressure of a substance is increased during a boiling process, will the temperature also increase or will it remain constant? Why?
11. What is the specific volume of saturated liquid water 300 kPa.
12. What is the specific volume of saturated vapor water 300 kPa.
13. What is the phase and enthalpy of water at 250 °C and 400 kPa.
14. What is the phase and enthalpy of water at 80 °C and 500 kPa.
15. What is the phase and enthalpy of water at 200 kPa and 0.7 quality.
16. What is the temperature of water at 5 MPa and 2,000 kJ/kg specific internal energy. Also determine its quality.

17. A 1.8 m^3 rigid tank contains steam at 220 °C. One-third of the volume is in the liquid phase and the rest is in the vapor form. Determine (a) the pressure of the steam, (b) the quality of the saturated mixture, and (c) the density of the mixture.
18. A rigid vessel contains 2 kg of refrigerant-134a at 800 kPa and 120 °C. Determine the volume of the vessel and the total internal energy.
   (answer: 0.0753 m^3, 655.7 kJ)
19. A piston-cylinder device initially contains 50 L of liquid water at 200 kPa and 40 °C. Heat is transferred to the water at constant pressure until the entire liquid is vaporized.
   a. What is the mass of the water?
   b. What is the final temperature?
   c. Determine the total enthalpy change.
   d. Show the process on a T-v diagram with respect to saturation line.
    (answer: (a) 49.61 kg, (b) 120.21 °C, (c) 125,943 kJ)
20. A 0.3 m^3 rigid vessel initially contains saturated liquid-vapor mixture at 150 °C. It is required that if the water were heated it would finally reaches the critical state. Determine the mass of the liquid and vapor at the initial state.
   (answer: liquid = 96.10 kg)
21. A piston-cylinder device contains 0.8 kg of steam at 300 °C and 1 MPa. Steam is cooled at constant pressure until one-half of the mass condenses.
   a. Show the process on a T-v diagram with respect to saturation line.
   b. Find is the final temperature?
   c. Determine the volume change.

22. A piston-cylinder device initially contains 50 L of liquid water at 200 kPa and 40 °C. Heat is transferred to the water at constant pressure until the entire liquid is vaporized.

a. What is the mass of the water?
b. What is the final temperature?
c. Determine the total enthalpy change.
d. Show the process on a T-v diagram with respect to saturation line.
    answer: (a) 49.61 kg, (b) 120.21 ^oC, (c) 125,943 kJ

23. A 0.3 m^3 rigid vessel initially contains saturated liquid-vapor mixture at 150 ^oC. It is required that if the water were heated it would finally reaches the critical state. Determine the mass of the liquid and vapor at the initial state. *(answer: liquid = 96.10 kg)*

24. A piston-cylinder device contains 0.8 kg of steam at 300 ^oC and 1 MPa. Steam is cooled at constant pressure until one-half of the mass condenses.
    a. Show the process on a T-v diagram with respect to saturation line.
    b. Find is the final temperature?
    c. Determine the volume change.

25. A rigid tank contains 10 kg of air at 150 kPa and 20 ^oC. More air is added to the tank until the pressure and temperature rise to 250 kPa and 30 ^oC, respectively. Determine the amount of air added to the tank.

26. A 1 m^3 tank contains air 25 ^oC 500 kPa is connected through a valve to another tank containing 5 kg of air at 200 kPa and 35 ^oC. Now the valve is opened, and the entire system is allowed to reach thermal equilibrium with the surroundings which are at 20 ^oC. Determine the volume of the second tank and the final equilibrium pressure of air. (answer:284.1 kPa)