Problems-2

2.1 Is iced water a pure substance? Why?

2.2 What is the difference between saturated vapor and superheated vapor?

2.3 Can the enthalpy of a pure substance at a given state be determined from a knowledge of u, P, and υ? How?

2.4 What is the physical significance of h_{fg}? can it be obtained from a knowledge of h_f and h_g ? How?

2.5 What is the quality? Does it have any meaning in the superheated region?

2.6 Complete the following table for H_2O:

T,°C	P, kPa	υ, m^3/kg	Phase description
60		4.131	
	300		Saturated liquid
250	200		
150	1000		

2.7 Complete the following table for H_2O:

T,°C	P,kPa	u, kJ/kg	Phase Description
20	5000		
150		631.68	
	225	2000	
	30		Saturated vapor
300		2600	

2.8 Complete the following table for H_2O:

T, °C	P, kPa	h, kJ/kg	Phase Description
500	200		
	175	486.99	
55		600	
400	4000		
255			Saturated vapor

2.9 Complete the following table for H_2O:

T, °C	P, kPa	υ, m^3/kg	x, if applicable	Phase Description
100	10000			
130		0.00107		
	550		.75	
	750	0.2556		
150	75			

2.10 Complete the following table for H_2O:

T, °C	P, kPa	U, kJ/kg	x, if applicable	Phase Description
200	10000			
200				Saturated liquid
200		1744.7		
200			1	
200	1000			

2.11 Complete the following table for H_2O:

T, °C	P, kPa	H, kJ/kg	x, if applicable	Phase Description
30	100			
	100		0.0	
	100	2000		
	100			Saturated vapor
	100	3074.3		

2.12 Determine whether the state of the following water system is compressed liquid, mixture of saturated liquid and saturated vapor, or superheated vapor.

(a) T=100°C, P=3.0MPa (b) T=300°C, P=100kPa

(c)T=100°C, υ=1.6m^3/kg (d) P=0.2MPa, u=700kJ/kg

2.13 Steam at 500kPa and a quality of 90 percent occupied a rigid vessel of volume 0.3m^3. Calculate the mass, internal energy, and enthalpy of the steam.

2.14 A rigid vessel of volume 0.2m^3 contains 10 kg of (liquid + vapor) water at 200°C. What are the pressure and internal energy of the water?

2.15 400-L rigid tank contains 5kg of water at 200kPa. Determine (a) the temperature, (b) the total enthalpy, and (c) the mass of each phase of water?

2.16 A rigid tank with a volume of 2.5m^3 contains 8kg of saturated liquid – vapor mixture of water at 100°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 lines?

2.17 Superheated water vapor at 1MPa and 300°C is allowed to cool at constant volume until the temperature drops to 120°C. At the final state, (a) the pressure (b) the quality, and (c)the enthalpy, also show the process on a T-v diagram with respect to saturation lines?

2.18 A piston- cylinder initially contains 100L of liquid water at 50°C and 300kPa. 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 lines?

2.19 A $1m^3$ rigid vessel initially contains saturated liquid-vapor mixture of water at 120°C. The water is now heated until reaches the critical state. Determine the mass of liquid water and the volume occupied by the liquid at the initial state.

2.20 Determine the specific volume, internal energy, and enthalpy of compressed liquid water at 100°C and 20MPa using the saturation approximation. Compare these values to the ones obtained from the compressed liquid tables?

2.21 Consider 1kg of water at its triple point. The volume of the liquid phase is equal to that of the solid phase, and the volume of the vapor phase is 10^4 times that of the liquid phase. Determine the mass of water in each phase at this state?

2.22 A cylinder-piston arrangement contains water at 105°C, 85% quality with a volume of 1L. the system is heated, causing the piston to rise and encounter a linear spring, as shown in Figure 33. at this point the volume is 1.5L, the piston diameter is 150mm, and the spring constant is 100N/mm. The heating continues, so the piston compress the spring. What is the temperature when the pressure reaches 200kPa?

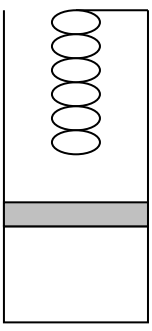

Figure 33. problem 2.34

2.23 A sealed rigid vessel of $2m^3$ contains a saturated mixture of liquid and vapor R-134a at 10°C. If it is heated to 50°C, the liquid phase disappears. Find the pressure at 50°C and the initial mass of the liquid.

2.24 Water in a piston-cylinder is at 90°C, 100kPa, and the piston loading is such that pressure is proportional to volume, P=CV. Heat is now added until the temperature reaches 200°C. Find the final pressure and the quality if in two-phase region.

2.25 A spring-loaded piston-cylinder contains water at 500°C, 3MPa. The setup is such that pressure is proportional to volume, P=CV. It is now cooled until the water becomes saturated vapor. Sketch the p-v diagram and find the final pressure.

2.26 Two tanks are connected, both containing water. Tank A is at 200kPa, $\upsilon=0.5m^3/kg$, $V_A=1m^3$ and tank B contains 3.5kg at 0.5MPa, 400°C. The valve is now opened and the two come to a uniform state. Find the final specific volume?

2.27 A rigid tank of $0.4m^3$volume is filled with steam at 2MPa and 250°C. The tank and contents are then cooled to 120°C. What will be the final amounts of saturated vapor and saturated liquid water(in kg), and what is the corresponding quality of the mixture?

2.28 A closed rigid vessel contains 2percent liquid and 98 percent water vapor by volume in equilibrium at 150°C. Determine the quality of the mixture. If the mixture is cooled to 100°C, what will be the quality and the liquid and vapor percentages by volume at the new state?

2.29 A rigid thermally insulated vessel contains 0.2kg of a liquid-vapor water mixture at 75kPa and quality of 30%. An electric heater supplies energy to the vessel till the pressure in the vessel reaches 200kPa. Determine (a) the volume of the vessel, (b) the quality of the mixture in the final state.

2.30 A rigid vessel of volume of $0.5m^3$ initially contains a water-vapor mixture at 0.6MPa. (a) If the quality of mixture is 40%, calculate the mass of the mixture. (b) If the pressure in the vessel is raised to 0.9MPa by the transfer of heat, what will be the mass of the vapor and mass of the liquid.

2.31 A spherical balloon with a diameter of 6m is filled with helium at 20°C and 200kPa. Determine the mole number and the mass of the helium in the balloon.

2.32 The air in an automobile tire with a volume of 0.015m^3 is at 30°C and 150kPa (gage). Determine the amount of air that must be added to raise the pressure to the recommended value of 200kPa (gage). Assume the atmospheric pressure to be 98kPa and the temperature and the volume to remain constant.

2.33 The pressure gage on a 1.2m^3 oxygen tank reads 500kPa. Determine the amount of oxygen in the tank if the temperature is 24°C and the atmospheric pressure is 97kPa.

2.34 A cylinder gas tank 1m long, inside diameter of 20cm, is evacuated and then filled with carbon dioxide gas at 25°C. to what pressure should it be charged if there should be 1.2 kg of carbon dioxide?

2.35 A hollow metal sphere of 150mm inside diameter is weighed on a precision beam balance when evacuated and again after being filled to 875 kPa with an unknown gas. The difference in mass is 0.0025kg, and the temperature is 25°C. What is the gas, assuming it is a pure substance.

2.36 A piston cylinder arrangement, shown in Figure 34, contains air at 250kPa, 300°C. The 50-kg piston has a diameter of 0.1m and initially pushes against the stops. The atmosphere is at 100kPa and 20°C. The cylinder now cools as heat is transferred to the ambient.
(a) at what temperature does the piston begin to move down?
(b) How far has the piston dropped when the temperature reaches ambient?

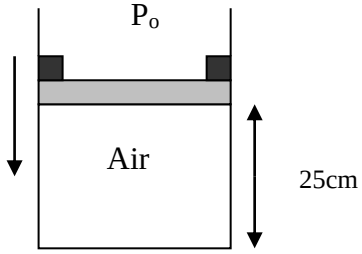

Figure 34 problem 2.49

2.37 Air in a tire is initially at –10°C, 190kPa. After driving awhile, the temperature goes up to 10°C. find the new pressure.

2.38 An initially deflated and flat balloon is connected by a valve to a 12m^3 storage tank containing helium gas at 2MPa and ambient temperature,

20°C. the valve is opened and the balloon is inflated at constant pressure P_o=100kPa, equal to ambient pressure, until it becomes spherical at D_1=1m. If the balloon is larger than this, the balloon material is starched giving a pressure inside as

$$P = P_o + C\left(1 - \frac{D_1}{D}\right)\frac{D_1}{D}$$

the balloon is inflated to a final diameter of 4m, at which point the pressure inside is 400kPa. The temperature remains constant at 20°C. What is the maximum pressure inside the balloon at any time during this inflating process? What is the pressure inside the helium storage tank at this time?

2.39 The helium balloon described in 2.48 is released into the atmosphere and rises to an elevation of 5000m, with a local ambient pressure of P_o=50kPa and temperature of –20°C. What is then the diameter of the balloon.

2.40 A rigid vessel A is connected to a spherical elastic balloon B as shown in figure 35. both contain air at the ambient temperature 25°C. The volume of the vessel A is 0.1m^3 and the initial pressure is 300kPa. The initial diameter of the balloon is 0.5m and the pressure inside is 100kPa. The valve connecting A and B is now opened, and remains open. It may be assumed that the pressure inside the balloon is directly proportional to its diameter, and also that the final temperature of the air is uniform throughout at 25°C. Determine the final pressure in the system and the final volume of the balloon?

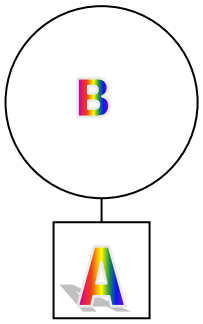

Figure 35. problem 2.53