Thermo 1 (MEP 261)

Thermodynamics An Engineering Approach

Yunus A. Cengel & Michael A. Boles

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Sheet 3:Chapter 3

3–26 Complete this table for H_2O:

T, °C	P, kPa	v, m³/kg	Phase description
50		4.16	
	200		Saturated vapor
250	400		
110	600		

3-26 *Complete the following table for H_2O:*

T, °C	P, kPa	v, m³ / kg	Phase description
50	***12.352***	4.16	***Saturated mixture***
120.21	200	***0.8858***	Saturated vapor
250	400	***0.5952***	***Superheated vapor***
110	600	***0.001051***	***Compressed liquid***

3–27 Reconsider Prob. 3–26. Using EES (or other) software, determine the missing properties of water. Repeat the solution for refrigerant-134a, refrigerant-22, and ammonia.

3–30 Complete this table for H_2O:

T, °C	P, kPa	h, kJ/kg	x	Phase description
	200		0.7	
140		1800		
	950		0.0	
80	500			
	800	3162.2		

Solution *Complete the following table for H_2O:*

T, °C	P, kPa	h, kJ / kg	x	Phase description
120.21	200	***2045.8***	0.7	***Saturated mixture***
140	***361.53***	1800	***0.565***	***Saturated mixture***
177.66	950	***752.74***	0.0	***Saturated liquid***
80	500	***335.37***	- - -	***Compressed liquid***
350.0	800	3162.2	- - -	***Superheated vapor***

3–31 Complete this table for refrigerant-134a:

T, °C	P, kPa	v, m^3/kg	Phase description
−8	320		
30		0.015	
	180		Saturated vapor
80	600		

Solution *Complete the following table for Refrigerant-134a:*

T, °C	P, kPa	v, m³ / kg	Phase description
-8	320	***0.0007569***	***Compressed liquid***
30	***770.64***	0.015	***Saturated mixture***
-12.73	180	***0.11041***	Saturated vapor
80	600	***0.044710***	***Superheated vapor***

3–32 Complete this table for refrigerant-134a:

T, °C	*P*, kPa	*u*, kJ/kg	Phase description
20		95	
−12			Saturated liquid
	400	300	
8	600		

Solution *Complete the following table for Refrigerant-134a:*

T, °C	P, kPa	*u*, kJ / kg	Phase description
20	***572.07***	95	***Saturated mixture***
-12	***185.37***	***35.78***	Saturated liquid
86.24	400	300	***Superheated vapor***
8	600	***62.26***	***Compressed liquid***

3–34 Complete this table for H_2O:

T, °C	*P*, kPa	*v*, m³/kg	Phase description
140		0.05	
	550		Saturated liquid
125	750		
500		0.140	

Solution *Complete the following table for H_2O:*

T, °C	P, kPa	v, m³ / kg	Phase description
140	***361.53***	0.05	***Saturated mixture***
155.46	550	***0.001097***	Saturated liquid
125	750	***0.001065***	***Compressed liquid***
500	***2500***	0.140	***Superheated vapor***

3–35 Complete this table for H_2O:

T, °C	P, kPa	u, kJ/kg	Phase description
	400	1450	
220			Saturated vapor
190	2500		
	4000	3040	

Solution *Complete the following table for H_2O:*

T, °C	P, kPa	u, kJ / kg	Phase description
143.61	400	1450	***Saturated mixture***
220	***2319.6***	***2601.3***	Saturated vapor
190	2500	***805.15***	***Compressed liquid***
466.21	4000	3040	***Superheated vapor***

3–36 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.

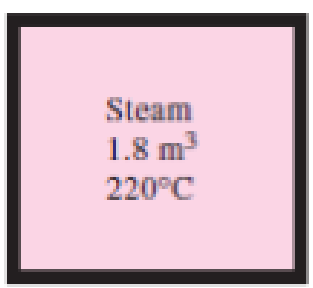


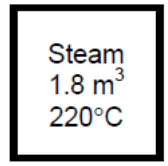
FIGURE P3–36

Solution A rigid tank contains steam at a specified state. The pressure, quality, and density of steam are to be determined.

Properties At 220°C v_f = 0.001190 m^3/kg and v_g = 0.08609 m^3/kg (Table A-4).

Analysis (*a*) Two phases coexist in equilibrium, thus we have a saturated liquid-vapor mixture. If the pressure of the steam is the saturation pressure at the given temperature, then the pressure in the tank must be the saturation pressure at the specified temperature,

$$P = T_{sat@220°C} = \mathbf{2320\ kPa}$$



(*b*) The total mass and the quality are determined as

$$m_f = \frac{V_f}{v_f} = \frac{1/3\times(1.8\ \text{m}^3)}{0.001190\ \text{m}^3/\text{kg}} = 504.2\ \text{kg}$$

$$m_g = \frac{V_g}{v_g} = \frac{2/3\times(1.8\ \text{m}^3)}{0.08609\ \text{m}^3/\text{kg}} = 13.94\ \text{kg}$$

$$m_t = m_f + m_g = 504.2 + 13.94 = 518.1\ \text{kg}$$

$$x = \frac{m_g}{m_t} = \frac{13.94}{518.1} = \mathbf{0.0269}$$

(*c*) The density is determined from

$$v = v_f + x(v_g - v_f) = 0.001190 + (0.0269)(0.08609) = 0.003474\ \text{m}^3/\text{kg}$$

$$\rho = \frac{1}{v} = \frac{1}{0.003474} = \mathbf{287.8\ kg/m^3}$$

3–37 A piston–cylinder device contains 0.85 kg of refrigerant-134a at −10°C. The piston that is free to move has a mass of 12 kg and a diameter of 25 cm. The local atmospheric pressure is 88 kPa. Now, heat is transferred to refrigerant-134a

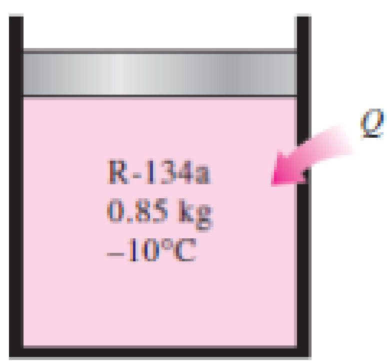


FIGURE P3–37

Solution A piston-cylinder device contains R-134a at a specified state. Heat is transferred to R-134a. The final pressure, the volume change of the cylinder, and the enthalpy change are to be determined.

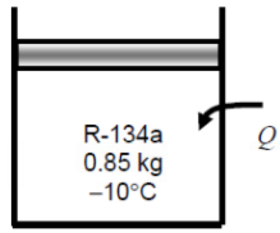
Analysis (a) The final pressure is equal to the initial pressure, which is determined from

$$P_2 = P_1 = P_{atm} + \frac{m_p g}{\pi D^2/4} = 88\text{ kPa} + \frac{(12\text{ kg})(9.81\text{ m/s}^2)}{\pi(0.25\text{ m})^2/4}\left(\frac{1\text{ kN}}{1000\text{ kg.m/s}^2}\right) = \mathbf{90.4\text{ kPa}}$$

(b) The specific volume and enthalpy of R-134a at the initial state of 90.4 kPa and −10°C and at the final state of 90.4 kPa and 15°C are (from EES)

$v_1 = 0.2302\text{ m}^3/\text{kg}$ $\quad h_1 = 247.76\text{ kJ/kg}$

$v_2 = 0.2544\text{ m}^3/\text{kg}$ $\quad h_2 = 268.16\text{ kJ/kg}$



The initial and the final volumes and the volume change are

$$V_1 = m v_1 = (0.85\text{ kg})(0.2302\text{ m}^3/\text{kg}) = 0.1957\text{ m}^3$$

$$V_2 = m v_2 = (0.85\text{ kg})(0.2544\text{ m}^3/\text{kg}) = 0.2162\text{ m}^3$$

$$\Delta V = 0.2162 - 0.1957 = \mathbf{0.0205\text{ m}^3}$$

(c) The total enthalpy change is determined from

$$\Delta H = m(h_2 - h_1) = (0.85\text{ kg})(268.16 - 247.76)\text{ kJ/kg} = \mathbf{17.4\text{ kJ/kg}}$$

3–77 The pressure gage on a 2.5-m^3 oxygen tank reads 500 kPa. Determine the amount of oxygen in the tank if the temperature is 28°C and the atmospheric pressure is 97 kPa.

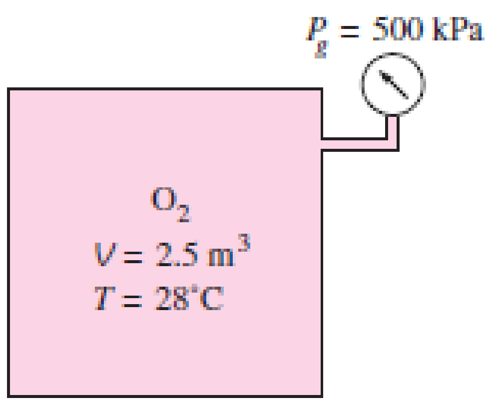
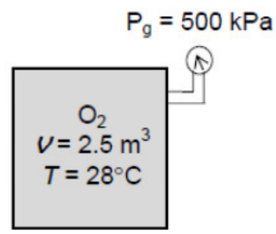


FIGURE P3–77

Solution The pressure and temperature of oxygen gas in a storage tank are given. The mass of oxygen in the tank is to be determined.

Assumption At specified conditions, oxygen behaves as an ideal gas.

Properties The gas constant of oxygen is $R = 0.2598$ kPa.m^3/kg.K (Table A-1).



Analysis The absolute pressure of O_2 is

$$P = P_g + P_{atm} = 500 + 97 = 597 \text{ kPa}$$

Treating O_2 as an ideal gas, the mass of O_2 in tank is determined to be

$$m = \frac{PV}{RT} = \frac{(597 \text{ kPa})(2.5 \text{ m}^3)}{(0.2598 \text{ kPa}\cdot\text{m}^3/\text{kg}\cdot\text{K})(28+273)\text{K}} = \mathbf{19.08\ kg}$$

3–80 A 1-m^3 tank containing air at 25°C and 500 kPa is connected through a valve to another tank containing 5 kg of air at 35°C and 200 kPa. 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. *Answers:* 2.21 m^3, 284.1 kPa

Solution Two rigid tanks connected by a valve to each other contain air at specified conditions. The volume of the second tank and the final equilibrium pressure when the valve is opened are to be determined.

Assumptions At specified conditions, air behaves as an ideal gas.

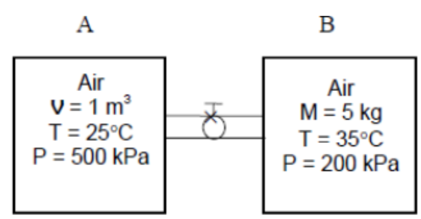
Properties The gas constant of air is $R = 0.287$ kPa.m^3/kg.K (Table A-1).

Analysis Let's call the first and the second tanks A and B. Treating air as an ideal gas, the volume of the second tank and the mass of air in the first tank are determined to be

$$V_B = \left(\frac{m_1 R T_1}{P_1}\right)_B = \frac{(5 \text{ kg})(0.287 \text{ kPa}\cdot\text{m}^3/\text{kg}\cdot\text{K})(308 \text{ K})}{200 \text{ kPa}} = \mathbf{2.21\ m^3}$$

$$m_A = \left(\frac{P_1 V}{R T_1}\right)_A = \frac{(500 \text{ kPa})(1.0 \text{ m}^3)}{(0.287 \text{ kPa}\cdot\text{m}^3/\text{kg}\cdot\text{K})(298 \text{ K})} = 5.846 \text{ kg}$$

Thus,



$$V = V_A + V_B = 1.0 + 2.21 = 3.21 \text{ m}^3$$

$$m = m_A + m_B = 5.846 + 5.0 = 10.846 \text{ kg}$$

Then the final equilibrium pressure becomes

$$P_2 = \frac{mRT_2}{V} = \frac{(10.846 \text{ kg})(0.287 \text{ kPa}\cdot\text{m}^3/\text{kg}\cdot\text{K})(293 \text{ K})}{3.21 \text{ m}^3} = \mathbf{284.1\ kPa}$$