Comprehensive Assignment

Question 1:

a. What is the difference between saturated vapor and superheated vapor?
b. Is it true that water boils at higher temperatures at higher pressures? Explain.
c. Complete the following table for H_2O:

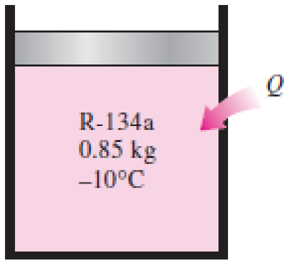
T, ° C	**P, kPa**	***h*, kJ / kg**	***x***	**Phase description**
	200		0.7	
140		1800		
	950		0.0	
80	500		- - -	
	800	3162.2	- - -	

d. Complete the following table for Refrigerant-134a:

T, ° C	**P, kPa**	**v, m3 / kg**	**Phase description**
-12	320		
30		0.0065	
	550		Saturated vapor
60	600		

Question 2:

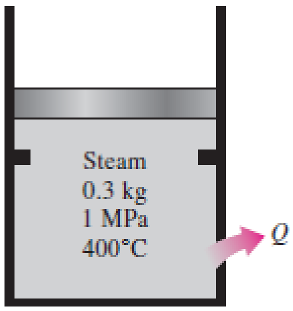
a. A piston–cylinder device contains 0.85 kg of refrigerant-134a at -10°C. The piston that is free to move has a mass of 12 kg and a diameter of 25 cm. The local atmospheric pressure is 88 kPa. Now, heat is transferred to refrigerant-134a



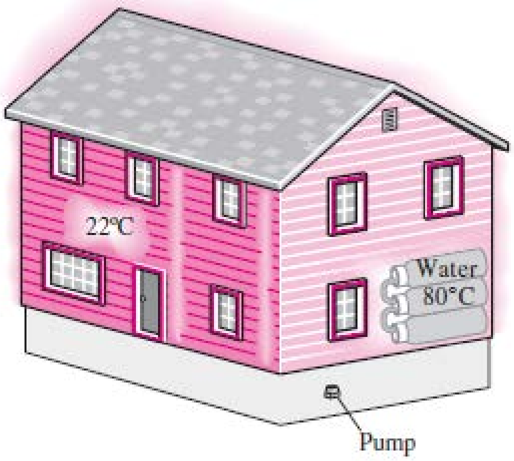
b. A 0.3-m3 rigid vessel initially contains saturated liquid–vapor mixture of water at 150°C. The water is now heated until it reaches the critical state. Determine the mass of the liquid water and the volume occupied by the liquid at the initial state.

Question 3:

a. A piston–cylinder device with a set of stops initially contains 0.3 kg of steam at 1.0 MPa and 400°C. The location of the stops corresponds to 60 percent of the initial volume. Now the steam is cooled. Determine the compression work if the final state is (a) 1.0 MPa and 250°C and (b) 500 kPa. (c) Also determine the temperature at the final state in part (b).



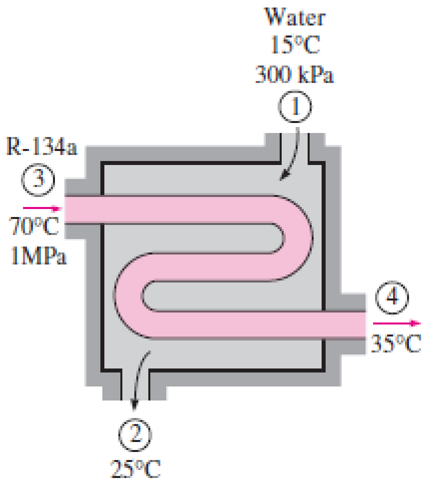
b. A passive solar house that is losing heat to the outdoors at an average rate of 50,000 kJ/h is maintained at 22°C at all times during a winter night for 10 h. The house is to be heated by 50 glass containers each containing 20 L of water that is heated to 80°C during the day by absorbing solar energy. A thermostat-controlled 15-kW back-up electric resistance heater turns on whenever necessary to keep the house at 22°C. (a) How long did the electric heating system run that night? (b) How long would the electric heater run that night in the house incorporated no solar heating?



Question 4

a. The power output of an adiabatic steam turbine is 5 MW, and the inlet and the exit conditions of the steam are as indicated in Fig. 5–28. (a) Compare the magnitudes of Δh, Δke, and Δpe.(b) Determine the work done per unit mass of the steam flowing through the turbine. (c) Calculate the mass flow rate of the steam.

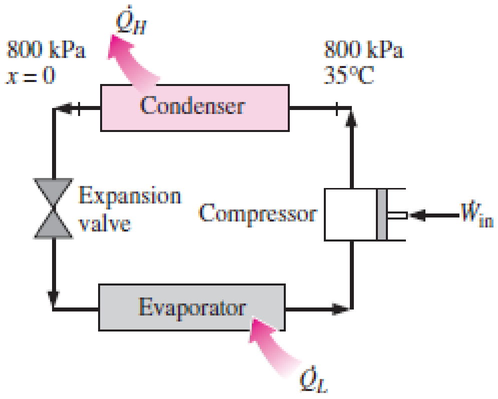
b. Refrigerant-134a is to be cooled by water in a condenser. The refrigerant enters the condenser with a mass flow rate of 6 kg/min at 1 MPa and 70°C and leaves at 35°C. The cooling water enters at 300 kPa and 15°C and leaves at 25°C. Neglecting any pressure drops, determine (a) the mass flow rate of the cooling water required and (b) the heat transfer rate from the refrigerant to water.



Question 5

a. Is it possible for a heat engine to operate without rejecting any waste heat to a low-temperature reservoir? Explain.

b. Refrigerant-134a enters the condenser of a residential heat pump at 800 kPa and 35°C at a rate of 0.018 kg/s and leaves at 800 kPa as a saturated liquid. If the compressor consumes 1.2 kW of power, determine (a) the COP of the heat pump and (b) the rate of heat absorption from the outside air.



Question 6

a. Steam enters an adiabatic turbine steadily at 3 MPa and 400°C and leaves at 50 kPa and 100°C. If the power output of the turbine is 2 MW, determine (a) the isentropic efficiency of the turbine and (b) the mass flow rate of the steam flowing through the turbine.
b. A rigid tank contains 5 kg of refrigerant-134a initially at 20°C and 140 kPa. The refrigerant is now cooled while being stirred until its pressure drops to 100 kPa. Determine the entropy change of the refrigerant during this process.

Question 7

a. What is the difference between spark-ignition and compression-ignition engines?
b. An ideal Otto cycle has a compression ratio of 8. At the beginning of the compression process, air is at 100 kPa and 17°C, and 800 kJ/kg of heat is transferred to air during the constant-volume heat-addition process. Accounting for the variation of specific heats of air with temperature, determine (a) the maximum temperature and pressure that occur during the cycle, (b) the network output, (c) the thermal efficiency, and (d) the mean effective pressure for the cycle.