Homework 2 ANS

1. Please consider the questions below and give your own answers.

(1) Why are the temperature and pressure dependent properties in the saturated mixture region?

ANS: Because one cannot be varied while holding the other constant. In other words, when one changes, so does the other one.

(2) Does the reference point selected for the properties of a substance have any effect on thermodynamic analysis? Why?

ANS: No. Because in the thermodynamic analysis we deal with the changes in properties; and the changes are independent of the selected reference state.

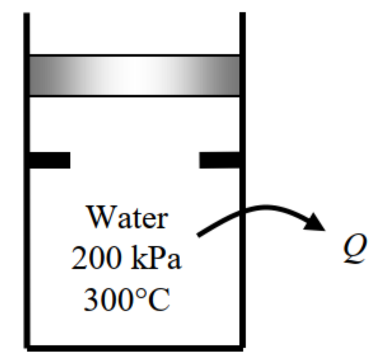
2. Complete this table for refrigerant-134a:

***T*, °C**	***P*, kPa**	**v, m^3/kg**	**Phase description**
-4	320	0.00076	Compressed liquid
10	415	0.0065	Saturated mixture
33.4	850	0.024	Saturated vapor
90	600	0.046	Superheated vapor

3. Water initially at 200 kPa and 300°C is contained in a piston-cylinder device fitted with stops. The water is allowed to cool at constant pressure until it exists as a saturated vapor and the piston rests on the stops. Then the water continues to cool until the pressure is 100 kPa. On the *T*-*v* diagrams sketch, with respect to the saturation lines, the process curves passing through both the initial, intermediate, and final states of the water. Label the *T*, *P* and *v* values for end states on the process curves. Find the overall change in internal energy between the initial and final states per unit mass of water.

ANS: The process is shown on *T*-*V* diagram. The internal energy at the initial state is

$$\left.\begin{aligned} P_1 &= 200\,\text{kPa} \\ T_1 &= 300°\text{C} \end{aligned}\right\} u_1 = 2808.8\,\text{kJ/kg} \quad (\text{Table A - 6})$$

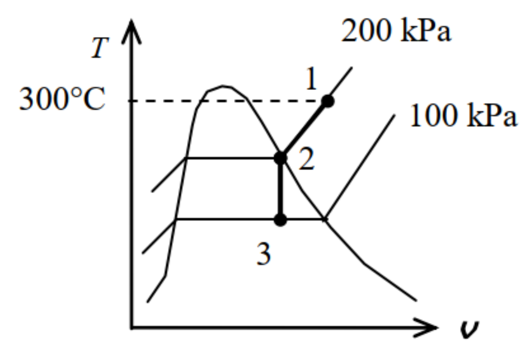


State 2 is saturated vapor at the initial pressure. Then,

$$\left.\begin{aligned} P_2 &= 200\,\text{kPa} \\ x_2 &= 1\,(\text{sat. vapor}) \end{aligned}\right\} \boldsymbol{v}_2 = 0.8858\,\text{m}^3/\text{kg} \quad (\text{Table A - 5})$$

Process 2-3 is a constant-volume process. Thus,

$$\left.\begin{aligned} P_3 &= 100\,\text{kPa} \\ \boldsymbol{v}_3 &= \boldsymbol{v}_2 = 0.8858\,\text{m}^3/\text{kg} \end{aligned}\right\} u_3 = 1508.6\,\text{kJ/kg} \quad (\text{Table A - 5})$$



The overall change in internal energy is

$$\Delta u = u_1 - u_3 = 2808.8 - 1508.6 = \mathbf{1300\,kJ/kg}$$

4. The positive pressure gage on a 3-m^3 oxygen tank reads 500 kPa. Determine the amount of oxygen in the tank if the temperature is 30 °C and the atmospheric pressure is 100 kPa.

ANS: The absolute pressure of O_2 is

$$P = P_g + P_{atm} = 500 + 100 = 600\text{kPa}$$

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

$$m = \frac{PV}{RT} = \frac{(600\text{kPa})\left(3.0\text{m}^3\right)}{\left(0.2598\text{kPa}\cdot\text{m}^3/\text{kg}\cdot\text{K}\right)(30+273)\text{K}} = 22.87\text{kg}$$

5. A rigid tank whose volume is unknown is divided into two parts by a partition. One side of the tank contains an ideal gas at 925°C. The other side is evacuated and has a volume twice the size of the part containing the gas. The partition is now removed and the gas expands to fill the entire tank. Heat is now applied to the gas until the pressure equals the initial pressure. Determine the final temperature of the gas.

ANS: According to the ideal gas equation of state,

$$P_2 = P_1$$

$$V_2 = V_1 + 2V_1 = 3V_1$$

Applying these,

$$m_1 = m_2 \qquad \frac{V_1}{T_1} = \frac{V_2}{T_2} \qquad \frac{P_1V_1}{T_1} = \frac{P_2V_2}{T_2}$$

$$T_2 = T_1\frac{V_2}{V_1} = T_1\frac{3V_1}{V_1} = 3T_1 = 3(925+273)\text{K} = 3594\text{K} = 3321^\circ\text{C}$$