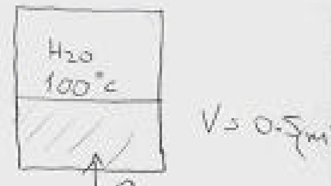
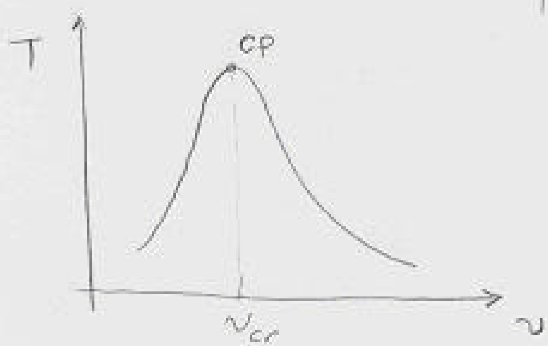
Suggested problems. for chapter 2

1)



This is a constant volume process ($v = V/m$ = constant) to the critical state, and thus the initial specific volume will be equal to the final specific volume, which is equal to critical specific vol.



$$m = \frac{V}{v} = \frac{0.5\,(m^3)}{0.003155\,(m^3/kg)}$$

$$m = 158.48\,(kg)$$

at $100^\circ c$ $\begin{cases} v_f = 0.001044\,(m^3/kg) \\ v_g = 1.6729\,(m^3/kg) \end{cases}$

$$x_1 = \frac{v_1 - v_f}{v_{fg}} = \frac{0.003155 - 0.001044}{1.6729 - 0.001044} = 0.001263$$

Then the mass of the liquid and its vol at the initial state are:

$$m_f = (1 - x_1)\,m_t = (1 - 0.001263)(158.48) = 158.28\,(kg)$$

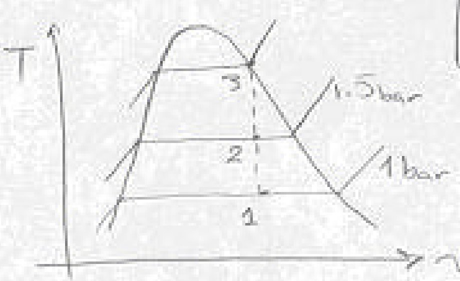
$$V_f = m_f v_f = (158.28\,(kg))\,(0.001044\,m^3/kg) = 0.165\,(m^3)$$

2)

$P_1 = 1$ bar , $x_1 = 0.5$

$P_2 = 1.5$ bar

$x_3 = 1.0$



$V = 0.5$ (m

Assumptions:

- the water in the container is a closed system.
- States 1, 2 and 3 are equilibrium states.
- The volume of the container remains constant

Analysis

for each state, two independent properties are needed.

At initial state (1), the pressure and quality are known.

$$v_1 = v_{f_1} + x(v_{g_1} - v_{f_1}) \qquad @\ P = 1 \text{ bar} \begin{cases} v_{f_1} = 1.0432 \times 10^{-3} (\\ v_{g_1} = 1.694 \ (m \end{cases}$$

$$v_1 = 1.0432 \times 10^{-3} + 0.5(1.694 - 1.0432 \times 10^{-3}) = 0.8475 \ (m^3/kg)$$

At state (2), the pressure is known. Since the volume and the mass are constant, so $v_2 = v_1 = v_3$

For $P_2 = 1.5$ bar $\longrightarrow \begin{cases} v_{f_2} = 1.0582 \times 10^{-3} \ (kg/m^3) \\ v_{g_2} = 1.159 \ (m^3/kg) \end{cases}$

Since $v_{f_2} < v_2 < v_{g_2}$ State 2 must be in two-phase region

Since states 1, 2 are in the two phase region, the temperatures correspond for the given pressures can be found in the table.

$\underline{T_1 = 99.63°C}$ and $\underline{T_2 = 111.4°C}$

Mass of water can be found :

$$m = \frac{V}{v} = \frac{0.5\,(m^3)}{0.8475\,(m^3/kg)} = 0.59\,(kg)$$

the mass of vapor at state 1 can be calculated as:

$$m_{g_1} = x_1\, m = 0.5\,(0.59\,(kg)) = 0.295\,(kg)$$

The mass of vapor at state (2) is found similarly using the quality x_2.

$$x_2 = \frac{v - v_{f2}}{v_{g2} - v_{f2}}$$

$$= \frac{0.8475 - 1.0528 \times 10^{-3}}{1.159 - 1.0528 \times 10^{-3}} = 0.731$$

$$m_{g_2} = x_2 \cdot m = 0.731 \times (0.59\,kg) = \underline{0.431\,(kg)}$$

If heating continued, state (3) would be on the saturated vapor line. Thus, the pressure would be the corresponding saturation pressure. Using Table, at $v_{g_3} = 0.8475\,(m^3/kg)$, $\rightarrow \underline{\underline{P_3 = 2.11\,(bar)}}$

3)

The gas constant, the critical pressure, and the critical temperature of refrigerant -134a, from Table, are:

$R = 0.08149 \left(\frac{kPa\ m^3}{kg \cdot K}\right) \quad T_{cr} = 374.25\,(K) \quad P_{cr} = 4.067\,(MPa)$

$$v = \frac{V}{m} = 0.01677\ (m^3/kg)$$

a) From the ideal gas equation of state:

$T = 110 + 273.15 = 383.15\ (K)$

$$P = \frac{RT}{v} = \frac{0.08149\,(kPa\,m^3/kg \cdot K) \times 383.15\,(K)}{0.01677\,(m^3/kg)} = \underline{1861.8}\ (kPa)$$

b) from the compressibility chart (Fig-A-13),

R-134a
1 MPa
0.0271 (m^3/kg)

$$\begin{cases} T_r = \dfrac{T}{T_{cr}} = \dfrac{383.15}{374.25} = 1.024 \\[2ex] v_r = \dfrac{v}{RT_{cr}/P_{cr}} = \dfrac{0.01677\,(m^3/kg) \times 4.067 \times 10^3\,(kPa)}{0.08149\left(\frac{kPa\,m^3}{kg \cdot K}\right) \times 374.25\,(K)} = 2.236 \end{cases}$$

From Fig A-13 $\quad \rightarrow P_r \cong 0.39$

$P = P_r \cdot P_{cr} = 0.39 \times 4.067\,(MPa) = 1.586\,(MPa)$

Solution to problem 4

Known

State (1), P1= 0.4 (MPa) and T1= -12 (C)
State (2), P2=P1 and V2=20V1
State (3), V3=V2 and T1= 52 (C)

Find h1, h2, and h3. Show the process on T-v diagram.

Solution

At T= -12 (C) from Table A-8, one can look up P_{sat1}=0.1854 (MPa). Since, P1>P_{sat1}, therefore, state (1) is compressed liquid. We do not have a compressed liquid table for R-134a, so: $v1= v_{f1}$ (-12C)=0.0007498 (m^3/kg)

$h1= h_{f1}+xh_{fg1}$
h1= 34.39(kJ/kg) + 0.0007498(m^3/kg) (0.4-0.1854) x1000 (kPa) = 34.55091 (kJ/kg)

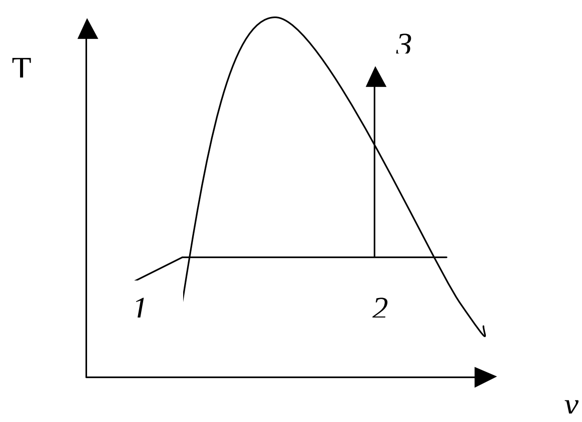
For state (2), we know $v2=20v1$=0.014996(m^3/kg) and P2=P1=0.4 (MPa)
Using table A-9: $v_{f2} < v2 < v_{g2}$ (at 0.4 MPa), so state (2) is saturated mixture ($T_{sat.2}$ = 8.93 C)
$X2= (v2-v_{f2})/(v_{g2}-v_{f2}), x2=0.28349$

$h2=h_{f2}+x_{hfg}$
h2= 62 (kJ/kg) +0.28349x 190.32 (kJ/kg) = 115.95 (kJ/kg)

For state (3) we have T3=52 C and v3=0.014996(m^3/kg), from Table A-8, v_g=0.0142(m^3/kg) <v3 thus, state (3) is superheated vapor.

Point	*v(m^3/kg)*	*P (MPa)*	*T (C)*	*h(kJ/kg)*
1	0.01495	1.4	60	283.10
2	0.01603	1.4	70	295.31

Using linear interpolation; h3=282.9258 (kJ/kg)



Problem 5

T (C)	*P (MPa)*	*x*	*h (kJ/kg)*	*v* (m^3/kg)	*u (kJ/kg)*
40	0.00738	0.0054	178.58	0.106	179.78
130.6	0.275	0.299	1200	0.1977	1144.17
250	0.01	Superheated vapor	2977.3	24.136	2736.0
250	2.5	Superheated vapor	2880.1	0.087	2662.6
100	2	Compressed liquid	421.02	0.001044	417.36