DO NOT WRITE ON THE BLUE TABLES. RETURN THE BLUE TABLES WITH YOUR EXAM. DO NOT STAPLE THE EXAM SHEETS TOGETHER. Put your answers on the same sheet as the question, Use many digits in your computation. You must give the units of your answers. You must write clearly. Encircle the right answer number in multiple choice. To correct, erase the wrong circle as well as you can and encircle the corrected answer number twice. Best possible answer for multiple choice. For questions asking a number, putting the clear correct formula(s) below the question might result in partial credit even if the answer is wrong. *Not following those requirements will result in reduced or no credit.*

1. (5%) A manometer filled with light oil, and at one end open to the atmosphere, shows a deflection of 20 cm. The gage pressure being measured is 1.785 kPa

2. (5%) A piston with a weight of 300 N and a diameter of 5 cm seals a substance in a cylinder. The gage pressure inside the cylinder is 152.788 kPa.

3. (5%) Which of the below information would be sufficient to figure out the pressure, temperature, and volume of water:

   (a) P and V.
   (b) v and x
   (c) T and m

4. (5%) 5 kmol of di-atomic oxygen has a mass of 160 kg

5. (5%) Saturated liquid is contained within a constant pressure piston-cylinder container. If the temperature is raised just a little bit, it turns into:

   (a) compressed liquid.
   (b) liquid-vapor mixture.
   (c) vapor.

6. (5%) The air pressure in Potosi, Bolivia, is about 61 kPa. Water will boil there at 87 °C

7. (5%) Liquid water at 50 MPa and 20°C will have a density of 1020 in units of $\mathrm{kg/m^3}$.

8. (33%) A rigid container is filled with water initially at 15°C and 50 m^3/kg. The temperature is then changed until the water turns into saturated vapor.

   (a) Construct the initial phase of the water in a very neat Tv-diagram, marking all lines and points used to do it with their values.

   (b) Give the initial pressure and quality, and the final temperature and quality, where defined, to as many digits as possible.

   (c) Show the process in a very neat Tv-diagram.

   Items are not equal credit.

   You must show the derivations and reasoning completely and correctly for full credit. You must give units for your answers. Most accurate procedure only unless stated otherwise.

Given in black

(8)

rigid container

① H_2O, 15°C, 50 m^3/kg

temperature change, isochoric

② Sat Vap → $x=1$ ($v=v_g$)

$m_2 = m_1$, $V_2 = V_1$ } $v_2 = v_1 = 50\ m^3/kg$

Asked

a) Initial phase, constructed, ~~mark~~

b) Initial pressure

c) Initial quality, to six digits accuracy.

d) ~~Final temperature and temperature change~~ Final temperature, 3 digits

e) Process in T v diagram, mark process

$T v_1$ { diagram ②; line 1 ②; coding + lines ②; line 2 ②; ~~phase~~ }

P_1 ③

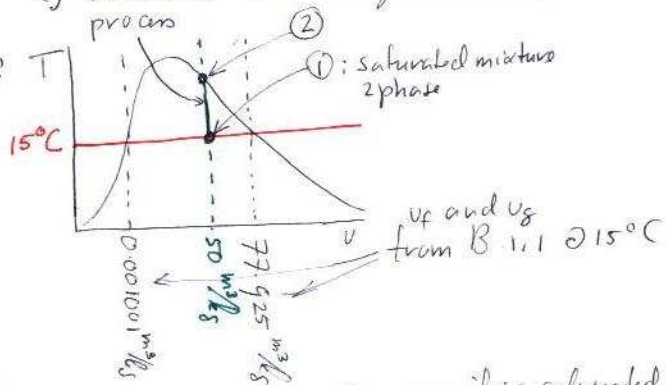
x_1 { eq ⑤; solve ④ }

T_2 { idea ⑤; interpol ④ }

x_2 ②

process ②

Solution



v_f and v_g from B.1.1 @ 15°C

a) Since $0.001001 < 50 < 77.925$, it's saturated mixture

b) Saturated → $p = 1.705$ kPa from B.1.1 @ 15°C

c) $v = v_f + x(v_g - v_f)$ all in m^3/kg

$50 = 0.001001 + x(77.925 - 0.001001)$

$\Rightarrow x = (50 - 0.001001)/(77.925 - 0.001001) =$

$= 0.641638002$

d) $v_g = 50\ m^3/kg$; $g_g = 50\ m^3/kg$ $\quad g_1 = 57.7897\ m^3/kg$ $\quad g_2 = 43.3593\ m^3/kg$

$d_1 = 20°C$ $\quad d_2 = 25°C$

$T_2 = d_1 + \frac{g - g_1}{g_2 - g_1}(d_2 - d_1) = 22.7°C$ $\quad x_2 = 1.000000000$

e) See graph

9. (32%) A pressure vessel with a volume of $2m^3$ contains 3 kg of a gas with a molecular mass of 23 at 15°C.

   (a) Give the pressure in atmospheres to at least 5 digits assuming that it is an ideal gas.

   (b) What is the gage pressure if the ambient pressure is 1 atm?

   (c) What can you say about the ideal gas assumption if all you know about the critical quantities is that the critical temperature is 150 K?

   (d) What can you say about the ideal gas assumption if all you know about the critical quantities is that the critical pressure is 10 MPa?

   Items are not equal credit.

   You must show the derivations and reasoning completely and correctly for full credit. You must give units for your answers. Most accurate procedure only unless stated otherwise.

Given In block

(9) pressurized container

$m = 3\,kg$ $V = 2\,m^3$

$M = 23 \frac{kg}{kmol}$ $T = 15^\circ C$

$pV = mRT$

$R = \frac{\bar{R}}{M}$

$\bar{R} = 8.3145 \frac{kJ}{kmol\,K}$ from A.1

Asked: a) Pressure in ~~atl~~ atmospheres, to ~~4~~ digits

b) gage pressure if ambient pressure is 1 atm

c) Ideal gas O.K. if $T_c = 150\,K$?

If $P_c = 10\,MPa$?

Solution:

$pV = mRT$ (6) $pV = m\frac{\bar{R}}{M}T$ → kN/m from A.1

$R = \frac{\bar{R}}{M}$ (5) → on n

$p\,2m^3 = 3kg \frac{8.3145 \frac{kJ}{kmol\,K}}{23 \frac{kg}{kmol}} (15 + 273.15)K$

$\bar{R} = 8.31..$ (5)

T → K (5)

p = ... (3)

(kPa) to atm (2)

$= 156.25 \frac{kN}{m^2} = 156.25\,kPa \frac{1\,atm}{101.325\,kPa} = 1.5421\,atm$

↑ kPa from A.1 ↑ from A.1

to p_{gage} (2)

$p_{gage} = 0.5421\,atm$

$T \approx 2T_c$ (2)

$p \approx \frac{P_c}{6}$ (2)

If $T_c = 150\,K$, then $T = 288\,K$ is about twice T_c

→ ideal gas should be O.K.

If $P_c = 10\,MPa$, then $P = 0.156\,kPa$ is much less than P_c, so ideal gas should be O.K. (if) it is a gas. (no liquid)