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 at least 5 digits in your computations and answers where possible. 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%) If you isobarically change compressed liquid into superheated vapor, the temperature will:

   (a) increase
   (b) stay the same
   (c) decrease

2. (5%) Under standard gravity, 3 kmol of water weighs 0.530 kN.

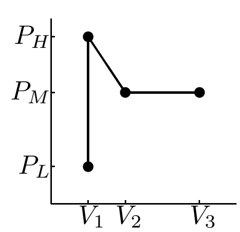
3. (5%) Given substance tables and molecular mass, what would be enough information to determine the number of moles:

   (a) P, v, and T.
   (b) ρ, v and T
   (c) V, v, and T

4. (5%) One end of a mercury-filled manometer is open to atmosphere and the other is connected to a pressurized container. If the deflection of the mercury is 20 cm, then the gage pressure inside the container is 26.635 kPa.

5. (5%) A lead piston with a volume of 0.003 m^3 and a cross sectional area of 0.004 m^2 floats on water in a cylinder. The ambient pressure is 100 kPa. The pressure in the substance is 183.41 kPa.

6. (5%) Write the expression for the work done in the shown process, in terms of V_1, V_2, V_3, P_L, P_M, and P_H.



$\frac{1}{2}(P_H + P_M)(V_2 - V_1) + P_M(V_3 - V_2)$.

7. (5%) The density of compressed liquid water at 30 kPa and 0.01°C equals 1,000 kg/m^3.

8. (33%) A piston floats on 3 kg water in a cylinder initially at a pressure of 3,000 kPa and a specific volume of 0.05 m^3/kg. Then the water is heated to 320°C.

   (a) Construct the initial phase of the water in a very neat Pv-diagram, marking all lines and points used to do it with their values. State the phase. Do not put more info in the diagram than is needed to construct the phase.

   (b) Find the initial temperature, and the quality if defined.

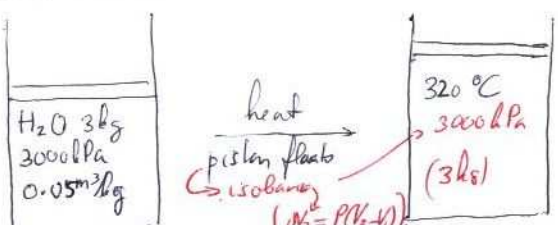
   (c) Using the obtained knowledge of the initial state, show the process as a fat line in a very neat Tv diagram. Explain why no phase construction is needed to find the final state.

   (d) Find the final volume.

   Items are not equal credit.

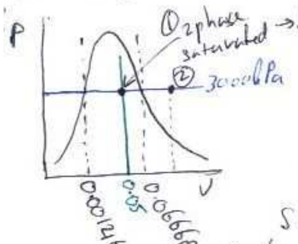
   You must show the derivations and reasoning completely and correctly for full credit. You must give simplified units for your answers. Most accurate procedure only unless stated otherwise. Use at least 5 significant digits in your computations and answers.

Given: in black



① diagram
~~① line 1~~
② find sat, right one
① plot sat
② line 2, relative pos
~~① ID~~
② Proc
① Explain 2
~~Graph work~~

Asked $(Pv)_1$, T_1, x_1 if def, $(Tv)_{proc,2}$, v_2, V_2, ~~graph work~~



→ B.1.2 is the one B.1.2: $T_1 = 233.90\,°C$

$v_1 = v_{f1} + x v_{fg1}$: $0.05 \frac{m^3}{kg} = (0.001216 + x\, 0.06546) \frac{m^3}{kg}$

$x = \frac{0.05 - 0.001216}{0.06546} = \underline{0.74525}$ $\quad \frac{0.05 - 0.001216}{0.06668 - 0.001216} = 0.7452$

~~$V_1 = m v_1 = 0.15\, m^3$~~

Since T goes up, 2 **must** be in superheated

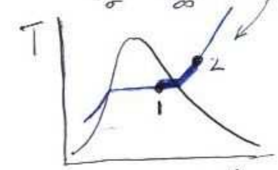


Table B.1.3 @ 3000kPa, 320 °C

$g = 320°C \quad g_1 = 300°C \quad g_2 = 350°C$ $\quad m^3/kg$

$d_1 = 0.08114 \quad d_2 = 0.09053$

$d = v = d_1 + \frac{g - g_1}{g_2 - g_1}(d_2 - d_1) = 0.08114 + \frac{320-300}{350-300}(0.09053 - 0.08114)$

$v_2 = \underline{0.084896\ m^3/kg}$ $\quad V_2 = m_2 v_2 = m_1 v_1 = 0.254680\ m^3$

② Read B.1.2 $T_{sat}(v_{f,fg})$
⑤ 2 phase formula
② compute x

③ Read B.1.3
⑥ interpolate
① $m_2 = m_1$
③ $V = mv$ units!

9. (32%) A piston-cylinder combination contains 2 kg of xenon at 20°C and 100 kPa. Then the xenon is compressed slowly, isothermally, to half the volume.

   (a) Based on the initial conditions, does it seem reasonable to treat the xenon as an ideal gas? Argue your answer. Assume for the remainder that it is an ideal gas either way.

   (b) What are the final volume, temperature, and mass?

   (c) What is the work done by the xenon in the process?

   Items are not equal credit.

   You must show the derivations and reasoning completely and correctly for full credit. You must give simplified units for your answers. Most accurate procedure only unless stated otherwise. Use at least 5 significant digits in your computations and answers.

Given: in black

① Xe; 2 kg E; 20°C I; 100 kPa I

compress isothermal → $V_2 = \frac{1}{2} V_1$ E; $T_2 = 20°C$

$PV = \text{constant}$

${}_1W_2 = PV \ln \frac{V_2}{V_1}$

Asked: I.G.? T_2? V_2? m_2? ${}_1W_2$?

Solution: $T_1 = T_2 = 20°C = (20 + 273.15)\,K = 293.15\,K$

Table A.2: $M = 131.3$ $T_c = 289.7$ $P_c = 5.84\,MPa = 5840\,kPa$

T is not twice or more T_c, but $P = 100\,kPa \ll P_c = 5840\,kPa$ → I.G. is OK,

and it is not liquid (above critical pt)

$n = \frac{m}{M} = \frac{2\,kg}{131.3\,kg/kmol} = 0.0152323\,kmol = n$

$P V = n \bar{R} T$ $\quad 100\,kPa\; V = 0.0152323\,kmol\; 8.31451\,\frac{kJ}{kmol\,K}\; 293.15\,K$

$V = 0.37127\,m^3$ $\quad R = \bar{R}/M = \frac{8.31451\,kJ/kmol\,K}{131.3\,kg/kmol} = 0.0633245\,\frac{kJ}{kg\,K} = R$

Alternatively,

$PV = mRT$ $\quad 100\,kPa\; V = 2\,kg\; 0.0633245\,\frac{kJ}{kg\,K}\; 293.15\,K$ $\quad V_1 = 0.371272\,m^3$

${}_1W_2 = P_1 V_1 \ln \frac{V_2}{V_1} = 100\,kPa\; 0.371272\,m^3 \ln \frac{1}{2} = -25.735\,kJ$ $\quad V_2 = \frac{1}{2} V_1 = 0.18564\,m^3$

~~Read A.2~~
~~Convert T to~~
~~Find R~~
~~Reasons for I.G.~~
~~$n = \frac{m}{M}$ and $PV = n$~~
~~or $R = \frac{\bar{R}}{M}$ and $PV =$~~
~~compute V_1 units~~

① ② Read A.2, find $\bar{R}$ and M

② Convert T to K

② Reasons for I.G.

⑤ ⑥ $\left\{ \begin{array}{l} n = \frac{m}{M} \text{ and } PV = n\bar{R}T \\ R = \frac{\bar{R}}{M} \text{ and } PV = mRT \end{array} \right.$

③ compute V_2 units 1+2

② $T_2 = T_1$

② $m_2 = m_1$

⑥ Work formula

① Compute ${}_1W_2$ units

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