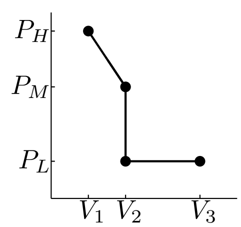
DO NOT WRITE ON THE BLUE TABLES. RETURN THE BLUE TABLES WITH YOUR EXAM. DO NOT STAPLE THE EXAM SHEETS TOGETHER. A letter-size formulae sheet, handwritten by you, may be used. Put your answers on the same sheet as the question. Use at least 5 significant digits in your computations and answers where possible. You must give the units of your answers. You must write clearly. 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%) 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. Use the standard formula for each process type from the class notes. It should be three expressions in the same order as the graph.



$\frac{1}{2}(P_H + P_M)(V_2 - V_1) + 0 + P_L(V_3 - V_2)$.

2. (5%) A mercury manometer has one leg connected to a container and the other leg open to the standard atmospheric pressure. The mercury in the leg connected to the container stands 8 cm *higher* than in the other leg. The absolute pressure in the container is 90.671 kPa and the gage pressure is -10.654 kPa.

3. (5%) There is boiling water inside a cylinder closed by a weighted piston. Half the mass of the water is vapor and the other half liquid. To get rid of all the vapor and have just liquid, you must (a) increase the temperature just a little bit; (b) keep the temperature the same but add just a little bit of weight to the piston; (c) decrease the temperature but not just a little bit. b

4. (5%) The ambient pressure is 100 kPa and gravity is standard. To obtain a pressure of 170 kPa below a floating piston in a cylinder with a 3 cm diameter requires a piston mass of 5.0459 kg

5. (5%) Given substance tables, what would be enough information to determine the pressure? (a) m, V, ρ; (b) m, V, T; (c) m, $\overline{n}$, T? b

6. (5%) For liquid water at 200 kPa and 80°C, using the given tables, but without using interpolation, the most accurate value for the density is: 971.82 kg/m^3.

7. (5%) Superheated water vapor at 1,600 kPa and 0.4 m^3/kg has a temperature of 1114.4 °C.

8. (33%) A spring-loaded piston-cylinder combination initially contains 0.5 kg of water at 300°C and 0.005 m^3/kg. Then the water cools down to 5,000 kPa and 0.001 m^3/kg.

   (a) You must construct all phases that are not given in *separate* Tv-diagrams, marking all lines and points used to do it with their values. Unambiguously number the states in the diagrams. Do not put more info in the diagrams than is needed to construct the phases. State the phases.

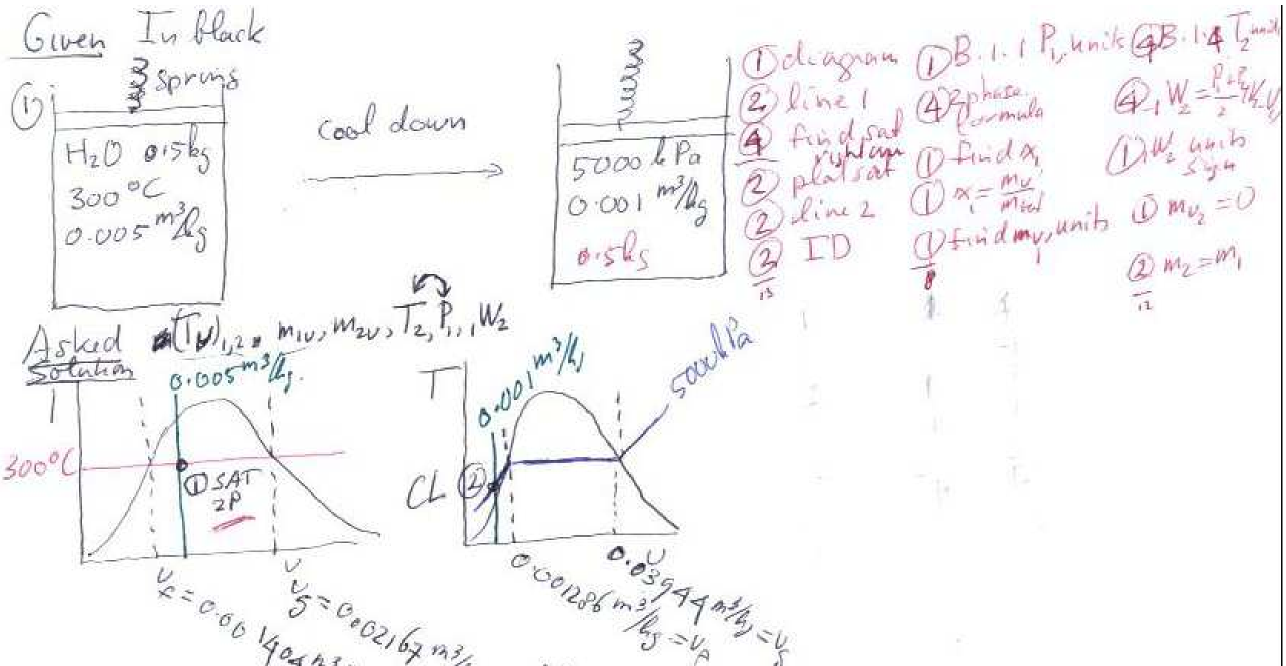
   (b) Find the initial pressure and the initial mass of water that is vapor.

   (c) Find the final temperature and final mass of water that is vapor.

   (d) Find the work done by the water in the process.

   Items are not equal credit. Remember, 5 significant digits throughout.

   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. *Give the source of every number.*



① is SAT → B-1.1 @ 300 $P_1 = 8581$ kPa

Also $v = v_f + x(v_g - v_f) \rightarrow x = (v - v_f)/(v_g - v_f)$

$x = 0.17744$ $m_{1v} = x m_1 = x\, 0.5\text{ kg} = 0.08872$ kg

② is C.L. → table B.1.4 @ 5000 kPa, 0.001 m^3/kg

→ $T_2 = 20$ °C

$_1W_2 = \frac{P_1 + P_2}{2}(V_2 - V_1) = \frac{8581\text{ kPa} + 5000\text{ kPa}}{2}\; 0.5\text{ kg}\,(0.001 - 0.005)\text{ m}^3/\text{kg}$

$(0.0005 - 0.0025)\text{ m}^3 = -0.002\text{ m}^3$

$= -13.581$ kJ

9. (32%) A piston-cylinder combination initially contains 0.5 kg of Xenon at 25°C and 1 atm. Then the Xenon is isothermally expanded until it reaches 0.2 m^3. *A typo made this 0.2 m^3/kg on the actual exam. As a result the correct work became 0.66814 kJ.*

   (a) Find the specific gas constant, the initial volume, and the work done by the Xenon in the expansion.

   (b) Would Xenon be a good ideal gas under the given conditions? Fully discuss the tests given in your notes, and for each test state what the conclusion based on that test is, if any. Then give the final conclusion based on all tests.

Items are not equal credit. Remember, 5 significant digits throughout.

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. *Give the source of every number.*

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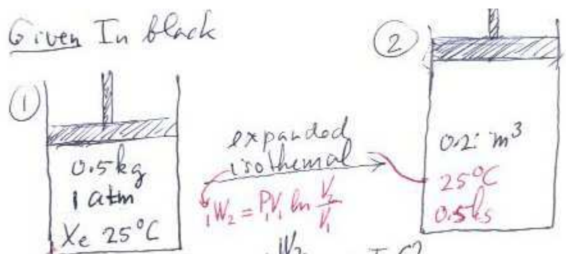

$R = R_u/M$ Asked R, V_1, ${}_1W_2$. Good I.G.?

Solution. $R = R_u/M = 8.31451 \frac{\text{kJ}}{\text{kmol K}} / 131.30 \frac{\text{kg}}{\text{kmol}} = 0.063325 \frac{\text{kJ}}{\text{kg K}}$

$P_1V_1 = mRT_1$ $\quad V_1 = mRT_1/P_1 = 0.5\text{ kg}\ 0.063325 \frac{\text{kJ}}{\text{kg K}} \underbrace{(25+273.15)}_{298.15}\text{K} / 101.325\text{ kPa}$

where kJ = kPa m^3 so $V_1 = 0.093167\text{ m}^3$

${}_1W_2 = 101.325\text{ kPa}\ 0.093167\text{ m}^3 \ln \frac{0.2\text{ m}^3}{0.093167\text{ m}^3} = 7.2116\text{ kJ}$

test 1) $T = 298.15\text{ K}$ $T_c = 289.7$ so T/T_c about 1 not $\geq \sim 2 \Rightarrow$ no conclusion

test 2 $P_1 = 101.325$ kPa and P_2 less. certainly less than $\frac{1}{10}$ 5.84 MPa $= 584$ kPa. In addition, it cannot be 2 phase or liquid since $T > T_c$ $\Rightarrow$ yes, good ideal gas

Yes good ideal gas.

(1) Find R_u
(1) Find M
(2) $R = R_u/M$
(2) units of R
(6) wrong or wrong intermediate (13) units, including no K, or wrong units in I.G. law

(7) Correct equation $PV = mRT$ (or equiv correct)
(2) T to Kelvin
(2) $V = mRT/P$ computation
(2) units of V

(5) Correct equation ${}_1W_2 = P_1V_1 \ln \frac{V_2}{V_1}$ or equiv
(2) ${}_1W_2 = P_1V_1 \ln V_2/V_1$ computation
(1) ${}_1W_2$ units
(8)
(2) test 1, discussion and conclusion (none)
(2) test 2, " " (very good)
(1) total conclusion (very good)