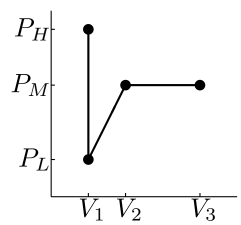
DO NOT WRITE ON THE BLUE TABLES. RETURN THE BLUE TABLES WITH YOUR EXAM. DO NOT STAPLE THE EXAM SHEETS TOGETHER. A letter-size formulae sheet, handwritten by you, may be used. Put your answers on the same sheet as the question. Use at least 5 significant digits in your computations and answers where possible. 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%) A manometer filled with 25°C water has one end closed, with the water vapor pressure at 25°C above the water. The other side is open to the atmospheric pressure of 100 kPa. The water in the closed leg stands __9.9037__ m higher than in the open leg.

2. (5%) The ambient pressure and gravity values are both standard. If a floating piston with a diameter of 7 cm has a mass of 30 kg, then the gage pressure below the piston is __76.446__ kPa and the absolute pressure is __177.77__ kPa.

3. (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 different expressions in the same order as the graph.



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

4. (5%) If you decrease the pressure a bit on saturated vapor while keeping the temperature the same, (a) it turns superheated vapor; (b) it turns 2 phase saturated; (c) it turns compressed liquid. __a__

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

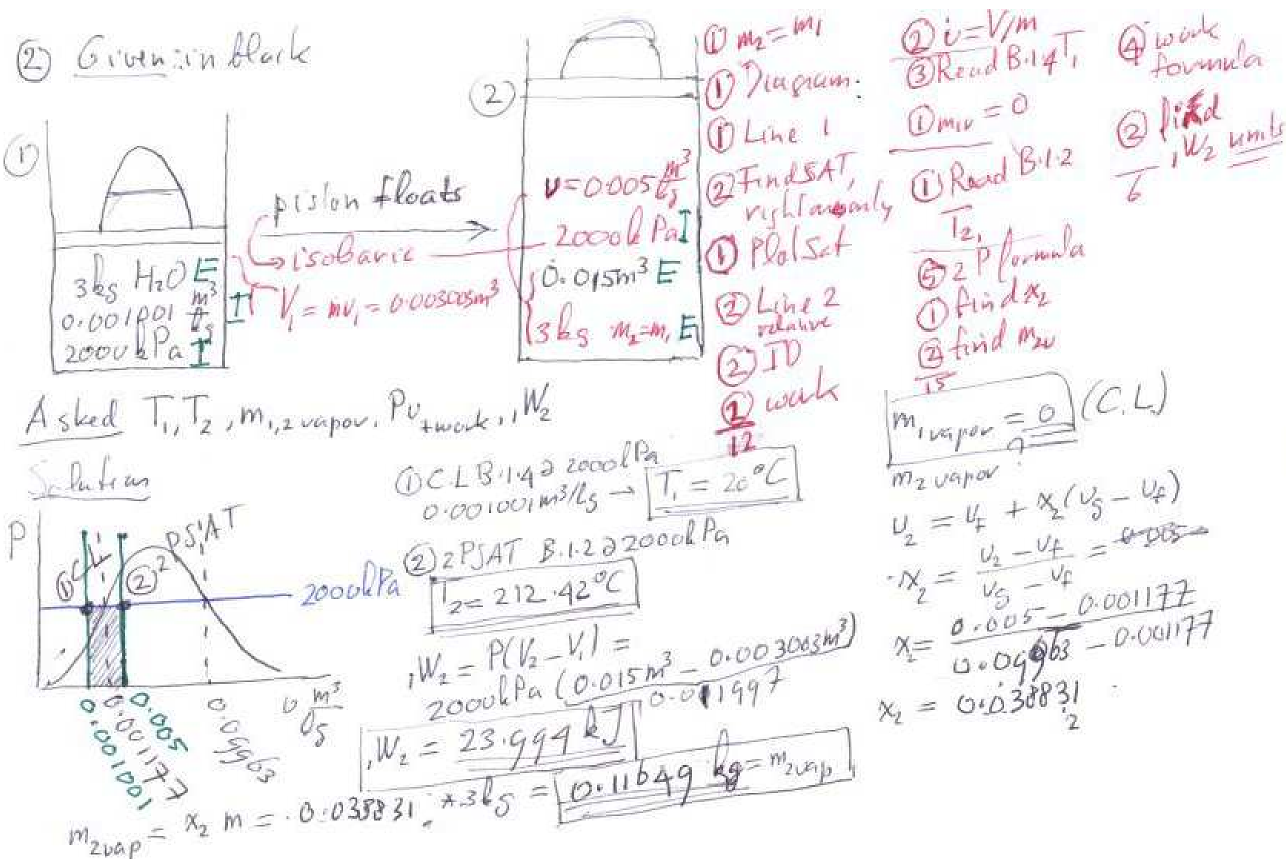
6. (5%) Referring to the attached sheet, for liquid amonia at about −25°C and 1000 kPa, the best value for the density without using interpolation is: __671.14__ kg/m^3.

7. (5%) For superheated water vapor at 600 kPa and 200°C, the molar specific volume is __6.3416__ in units of __m^3/kmol__.

8. (33%) A heavy piston floats on 3 kg of water at 2000 kPa and 0.001001 m^3/kg. Then the water is heated until the volume becomes 0.015 m^3.
   (a) Construct the initial and final phases in a very neat Pv-diagram. Mark 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 temperature 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.
   (e) Show the work graphically, neatly, in the same Pv diagram as before.

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.*



9. (32%) A piston-cylinder combination contains 3 kg of ammonia at 120 kPa and 4 m^3. Then the piston is pulled up until the pressure becomes half the initial pressure. It can be assumed that this process is polytropic with $n = 1.3$. Assume ammonia is an ideal gas in the first two questions.

   (a) How many degrees centigrade is the ammonia initially?

   (b) What is the work done by the ammonia in the process?

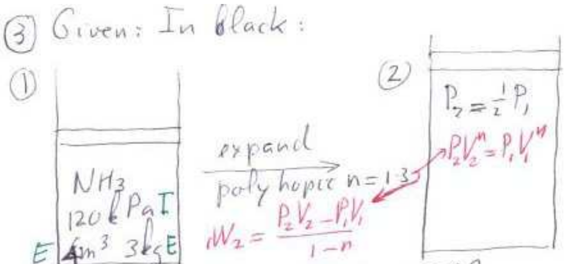
   (c) Based on the provided data sheet, what is the specific volume of saturated ammonia vapor at 60 kPa?

   (d) Would ammonia 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.*

③ Given: In black:



Asked T_1, ${}_1W_2$, v_g @ 60 kPa, Good I.G.?

Solution a) A 5 $R = 0.4882\ \frac{kJ}{kg\,K}$ $P_1V_1 = mRT_1$ 120 kPa 4 m^3 = 3 kg 0.4882 $\frac{kJ}{kg\,K}$ T_1

$T_1 = (120 * 4\ kJ)/(3 * 0.4882\ kJ/K) = 327.73\ K = \boxed{54.586\,°C = T_1}$

b) $P_2V_2^{1.3} = P_1V_1^{1.3}$ $V_2 = V_1\left(\frac{P_1}{P_2}\right)^{\frac{1}{1.3}} = 4\,m^3 \left(\frac{120}{60}\right)^{\frac{1}{1.3}} = 6.8174\ m^3$

${}_1W_2 = \frac{P_2V_2 - P_1V_1}{1-n} = \frac{-70.953\ kJ}{-0.3} = \boxed{236.51\ kJ = {}_1W_2}$

c) $g = 60$ kPa $g_1 = 54.5$ kPa $d_1 = 2.00632\ m^3/kg$ $d = v_{g\,60kPa} = d_1 + (d_2 - d_1)\frac{g - g_1}{g_2 - g_1}$

$g_2 = 71.7$ kPa $d_2 = 1.55256\ m^3/kg$

$= 2.00632\ \frac{m^3}{kg} + (1.55256 - 2.00632)\frac{m^3}{kg}\frac{60 - 54.5}{71.7 - 54.5}$ (.31977) $= \boxed{1.86122\ \frac{m^3}{kg} = v_{g\,60kPa}}$

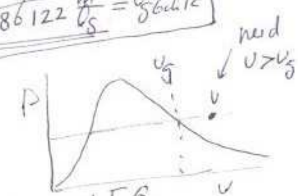
d) 1) $\frac{T_1}{T_c} = \frac{327.73}{405.5} < 1$; no conclusion

2) $\frac{P_1}{P_c} = \frac{120\ kPa}{11350\ kPa} = 0.0105 \rightarrow$ very good I.G. if it is SHV

$v_1 = \frac{4\ m^3}{3\ kg} = 1.333\ \frac{m^3}{kg} > v_{g120} \sim 0.96339\ \frac{m^3}{kg} \rightarrow$ SHV

$v_2 = \frac{6.817\,m^3}{3\ kg} = 2.272\ \frac{m^3}{kg} > v_{g60} = 1.86122 \rightarrow$ SHV

very good I.G.



② R from A.5 or equiv
⑤ PV = mRT Kor-2
① Find T
⑫ Convert to °C

③ $P_1V_1^n = P_2V_2^n$
① Find V_2
③ Work formula
① Find ${}_1W_2$ units
8

④ Interpolate
① $m_2 = m_1$
② Find $v_1, v_2 = V/m$
② Show SHV using diagram
9

② criterion 1 T/T_{cr} no conclusion
criterion 2 P/P_{cr}
③ good I.G. supersedes 1
5