EML 3100 Exam 1 **THERMODYNAMICS** **2/4/10 11:45-1:00 pm**
Page 1/3 Solutions (dommelen@eng.fsu.edu) series a

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 mercury experiences a pressure of 90 kPa at one side. The mercury stands 10 cm higher in the other side. The pressure at that side is 76.678 .

2. (5%) A substance in a cylinder with a radius of 3 cm is to be pressurized to 150 kPa. The ambient pressure is 100 kPa. The mass of the piston required to produce the desired pressure is 14.4 kg.

3. (5%) Given substance tables and the pressure and temperature, what would be enough additional information to determine the volume:
   - [✓ (a)] m.
   - (b) v.
   - (c) ρ.

4. (5%) 2 kg of nitrous oxide contains 45.44 mol of molecules.

5. (5%) If you isothermally reduce the pressure of saturated liquid a bit, it will become:
   - (a) compressed liquid.
   - (b) liquid-vapor mixture.
   - [✓ (c)] superheated vapor.

6. (5%) Which of the below can reasonably be assumed to be an ideal gas:
   - [✓ (a)] Carbon dioxide at 300 K and 100 kPa.
   - (b) Water at 300 K and 100 kPa.
   - (c) Xenon at 300 K and 5 MPa.

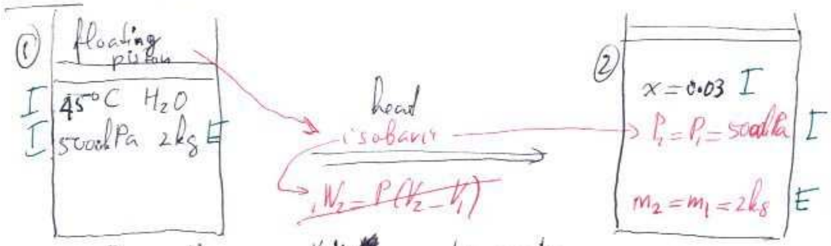
7. (5%) Water at 10 MPa has a specific volume of 0.002 m^3/kg. The quality is undefined / defined and equal to 3.31 %.

8. (33%) A piston-cylinder combination holds 2 kg of water at a temperature of 45°C and a pressure of 5000 kPa below a floating piston. Then the water is heated until the quality is 0.03.
   - (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. Use only the data given for the initial state.
   - (b) Also show the final phase in the diagram as point 2, and the process as a fat line.
   - (c) Find the initial and final volumes to at least 4 significant digits.

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 the maximum number of digits in your computations.

Given: In black:



① diagram
② line 1
② find sat
② draw sat
② line 2 and cross
① I D
② phase 2
② process

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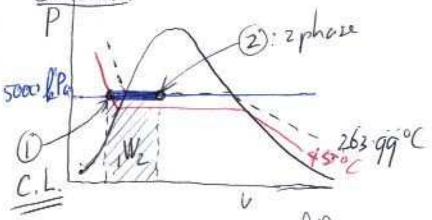
~~(5) interpolate~~
~~(5) $V = mv$, $V_2 = mv$~~
~~(5) $v_2 = v_f + x v_{fg}$~~
~~(5) Read B.1.2 v_f, v_{fg}~~
~~② $m_2 = m_1$~~
~~② $P_2 = P_1$~~

Asked; Pv, with process, V_1, V_2, ~~[illegible]~~, graphic work.

Solution:



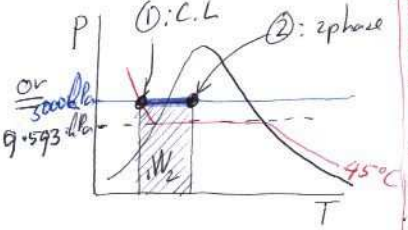


Table B.1.4 @ 5000 kPa

① $m_2 = m_1$
③ $P_2 = P_1$
② $V = mv$
② Read B.1.4
④ interpolate units
③ Read B.1.2
④ $v = v_f + x v_{fg}$ units

$T = 45°C$ $T_1 = 40°C$ $T_2 = 60°C$

$v_1 = 0.001006 \frac{m^3}{kg}$ $v_2 = 0.001015 \, m^3/kg$

$$v_1 = v = v_1 + \frac{T - T_1}{T_2 - T_1}(v_2 - v_1) = \left[0.001006 + \frac{45-40}{60-40}(0.001015 - 0.001006)\right]\frac{m^3}{kg}$$

$$= 0.00100825 \, m^3/kg$$

$$V_1 = m v_1 = 2 kg \; 0.00100825 \frac{m^3}{kg} = \underline{\underline{0.0020165 m^3}}$$

$$v_2 = v_{f_2} + x_2 v_{fg_2} = (0.001286 + 0.03 \; 0.03815) \, m^3/kg = 0.0024305 \, m^3/kg$$

$$V_2 = m v_2 = 2 kg \; 0.0024305 \frac{m^3}{kg} = \underline{\underline{0.004861 \, m^3}}$$

~~AP4 (0.004861 − 0.0020165) m^3~~

9. (32%) Air in a spring-loaded piston-cylinder combination is initially at 90 kPa and 25°C, with a volume of 0.25 m^3. The air is heated until the volume doubles and the temperature is 900 K.

   (a) What is the mass of the air?

   (b) What is the final pressure?

   (c) What is the work done in the expansion?

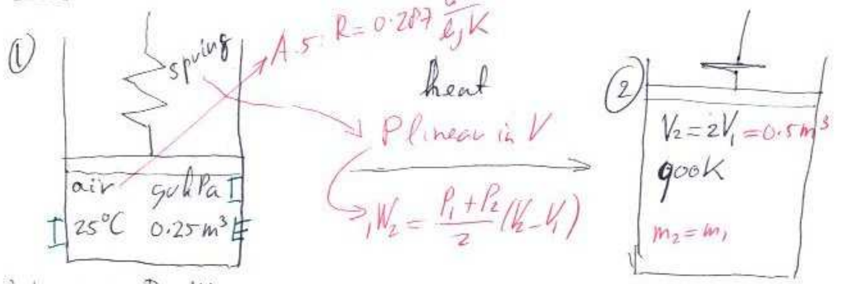
   (d) What is the specific work?

   (e) Show the process and the work done graphically in an accurate and neat PV diagram.

   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 the maximum number of digits in your computations.

Given: In black:



Asked: m, P_2, $_1W_2$

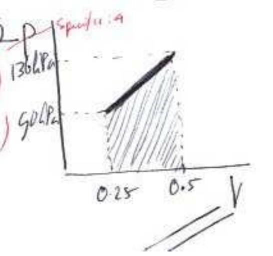
Solution: $P_1V_1 = mRT_1$ $\quad 90\text{ kPa}\ 0.25\text{ m}^3 = m\ 0.287\frac{kJ}{kg\,K}(273+25)\text{K}$

$\rightarrow m = \underline{\underline{.26308\text{ kg}}}$ $\quad$ (.262g using 273.15)

$P_2V_2 = mRT_2$ $\quad P_2\ 0.5\text{ m}^3 = .26308\text{ kg}\ 0.287\frac{kJ}{kg\,K}\ 900\text{ K}$

$P_2 = \underline{\underline{135.9\text{ kPa}}}$ $\quad _1W_2 = \frac{135.9+90}{2}\text{kPa}\ (0.5-0.25)\text{m}^3 = \underline{\underline{28.24\text{ kJ}}}$

$w = {_1W_2}/m = \underline{107.338\text{ kJ/kg}}$



③ Find R
⑥ PV = mRT → not linear
④ convert T
① compute m units!
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② $m_2 = m_1$
② V_2
① compute P_2 units!
5
② Pv process

⑥ work formula unreasonable: 2
① compute work (units!)
② $w = {_1W_2}/m$ (units!)
9
② graphical work.