EML 3100 Exam 2 **THERMODYNAMICS** **3/1/11 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 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%) A piston-cylinder combination contains 2 kg of saturated water currently at 110°C. The water is being compressed at a rate of 0.15 m^3/s and 5 kW of heat leaks out. The internal energy of the water changes at a rate of 16.495 kJ/s.

2. (5%) The specific heat at constant volume of butane at 326.85°C is 2.743256 kJ/kg-K.

3. (5%) A box with $2m^3$ of sand gets heated by the sun to 80°C. While cooling back down to 10°C, it will releases 168 MJ of heat.

4. (5%) If cubic zirconia has an internal energy of 40 kJ at 101.324 kPa and 0.7 m^3 then its enthalpy under the same conditions is 110.9275 kJ.

5. (5%) What would be enough info to find the specific volume of an ideal gas

   [✓ (a)] P and h
   (b) T and h
   (c) T and u

6. (5%) If 3 kg of acetylene is being heated at a rate of 0.5°C/s, its enthalpy changes at a rate of 2.5485 kJ/s.

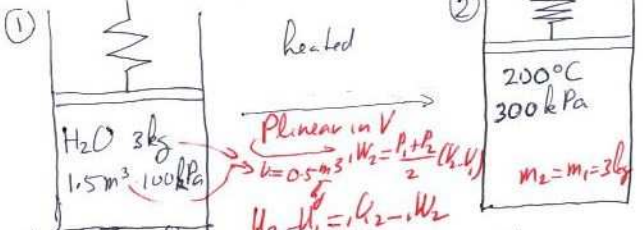
7. (5%) An isobaric container holds 3 kg of air that is near room temperature, but is being heated at a rate of .7 kW. The temperature increases at a rate of 0.2324 °C/s to 5 digits.

8. (33%) A spring-loaded piston-cylinder combination contains 3 kg of water within a volume of 1.5 m^3 at 100 kPa. Then the water is heated until the temperature reaches 200°C and the pressure 300 kPa.

    - Construct the initial and final phases 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.
    - Find the heat added to the water to at least 5 digits accuracy.

    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:



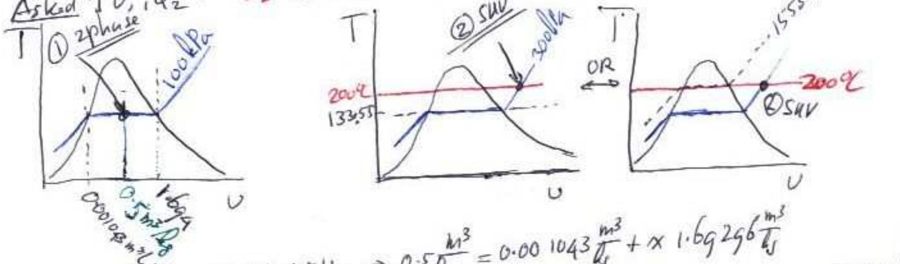
P linear in V

$v = 0.5 \frac{m^3}{kg}$, ${}_1W_2 = \frac{P_1+P_2}{2}(V_2-V_1)$

$U_2 - U_1 = {}_1Q_2 - {}_1W_2$

① diagram
② line 1
② find sat. relations
② plot sat
② line 2
② ID
11

Asked: Tv, ${}_1Q_2$



① B.1.2 @ 100 kPa: $v = v_f + x v_{fg} \rightarrow 0.5 \frac{m^3}{kg} = 0.001043 \frac{m^3}{kg} + x\, 1.69296 \frac{m^3}{kg}$

$\rightarrow x = \underline{0.294725}$ $u_1 = u_f + x u_{fg} = 417.33 + 0.29472\ 2088.72 = \underline{1032.93 \frac{kJ}{kg}}$

② B.1.3 @ 200°C, 300 kPa $v_2 = 0.71629$ $u_2 = 2650.65$

${}_1W_2 = \frac{P_1+P_2}{2}(V_2 - V_1) = \frac{P_1+P_2}{2} m(v_2 - v_1) = \frac{100+300}{2} kPa\ 3 kg\,(0.71629 - 0.5)\frac{m^3}{kg}$

$= 129.774\ kJ$

$U_2 - U_1 = {}_1Q_2 - {}_1W_2$ $m(u_2 - u_1) = {}_1Q_2 - {}_1W_2$

$\underbrace{3kg\underbrace{(2650.65 - 1032.93)}_{1617.72}}_{4853.16}\frac{kJ}{kg} = {}_1Q_2 - 129.774$ $\therefore {}_1Q_2 = \underline{\underline{4982.934\ kJ}}$

② read B.1.2
④ 2 phase formulae
① find x_1
① find u_1

③ Read B.1.3
① $m_2 = m_1$
④ work formula
8

⑤ 1st law u instead of U: -2
① compute ${}_1Q_2$ units!
6

9. (32%) A low velocity stream of 2 kg/s 626.85°C air at 110 kPa is mixed with a 200 m/s stream of 7 kg/s 26.85°C air also at 110 kPa in an adiabatic mixing chamber. The streams exit the mixing chamber at 105 kPa with low velocity.

   - What is the exit temperature to 5 digits?
   - What is the area of the 26.85°C entrance pipe?

   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:

Vel low velocity air

① 2 kg/s air E

T 626.85°C = 900K

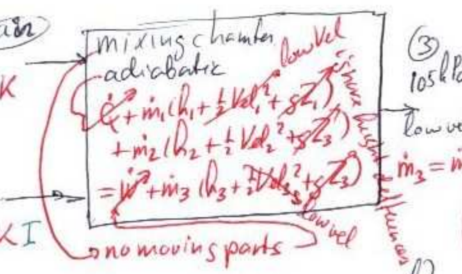
I 110 kPa

200 m/s Vel

② 7 kg/s E

26.85°C = 300K I

110 kPa I



③ 105 kPa I

low velocity Vel

$\dot{m}_3 = \dot{m}_1 + \dot{m}_2 = 9$ kg/s

$\dot{m}_3 = \dot{m}_1 + \dot{m}_2$

first law

$w = 0$

$q = 0$

normalize vel

find h_3

Asked : T_3, A_2

Solution: Table A.7.1 $h_1 = 933.15 \frac{kJ}{kg}$ $h_2 = 300.47 \frac{kJ}{kg}$

$$\dot{m}_1 h_1 + \dot{m}_2 (h_2 + \frac{1}{2}Vel_2^2) = \dot{m}_3 h_3$$

$$\underbrace{2\frac{kg}{s}\,933.15\frac{kJ}{kg}}_{18663} + \underbrace{7\frac{kg}{s}\left(300.47\frac{kJ}{kg} + \underbrace{\frac{1}{2}(200)^2\frac{m^2}{s^2}\frac{1\,\frac{kJ}{kg}}{1000\,m^2/s^2}}_{20}\right)}_{2243.29} = 9\frac{kg}{s}h_3$$

$h_3 = 456.6211$ kJ/kg

$g = 456.6211$ $g_1 = 441.93$ $g_2 = 462.34$

$d = T$ $d_1 = 440$ $d_2 = 460$

$$T = d_1 + \frac{g - g_1}{g_2 - g_1}(d_2 - d_1)$$

$$= 440 + \underbrace{\frac{456.6211 - 441.93}{462.34 - 441.93}}_{.715799662}(460 - 440)$$

$T = \underline{454.396 K}$

$P_2 v_2 = RT_2$ 110 kPa $v_2 = 0.287 \frac{kJ}{kg\,K}$ (A.5) 300K $v_2 = .782727$

$\dot{m}_2 = \frac{A\,Vel_2}{v_2}$ $7\,kg/s = \frac{A\ 200\ m/s}{.782727\ m^3/kg}$

$A = \underline{0.027395\ m^2}$

② convert to K

② Read R $P_v=RT$, table

② Read A.7.1 $h_1\,h_2$

$\overline{6}$

④ first law

③ $\dot{m}_3 = \dot{m}_1 + \dot{m}_2$

② $w = 0$

② $q = 0$

① normalize vel

① find h_3

~~know~~ can

② interpolate T_3

④ interpolate, units!

$\overline{6}$

④ $Pv = RT$

② $\dot{m} = \frac{A\,Vel}{v}$

① find A, units!

$\overline{7}$