EML 3002C Exam 2 **ME TOOLS THERMO** **10/19/20 3:30-4:45 pm**

 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. 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%) To keep a 2 kg/s stream of steam at 0.09 m^3/kg from moving at a speed exceeding 200 m/s, the diameter of the pipe that it moves through must be at least 3.3851 cm.

2. (5%) The specific heat at constant volume of air at 800 K is 0.81532 kJ/kg-K.

3. (5%) If you throw a 2 kg brick at 70°C in 4 kg of water (approximated as a simple liquid) at 25°C, then ignoring heat conduction with the surroundings, the two reach a common final temperature of 29.109 °C.

4. (5%) If acetylene at 500 K has an internal energy of 700 kJ/kg, then its enthalpy is 859.65 kJ/kg.

5. (5%) If you know U and m for an ideal gas for which you have tables, then you can find a) P; b) V; or c) T. c.

6. (5%) A piston-cylinder configuration holds 3 kg of air at 90 kPa and 25°C. The air is heated up by 0.5 kW of heat and is increasing in temperature by 0.15°C/s. So apparently the air is expanding at a rate of 0.0019706 m^3/s.

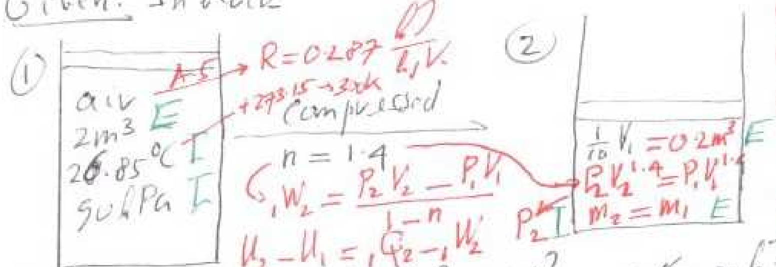
7. (5%) A weighted piston cylinder holds 3 kg of air at 200 kPa and 25 °C that is heating up at a rate of 0.2°C/s. The air is absorbing heat at a rate of 0.6024 kW.

8. (33%) A piston-cylinder combination initially holds 2 m^3 of air at 26.85°C and 90 kPa. Then the air is compressed to one tenth of its original volume. Presumably, this should be a polytropic process with $n = 1.4$.

   - Find the final mass of air. Also find the final pressure and temperature.
   - Find the work that must be done *on* the air to compress it, and the heat transfer *to* the air. (These will both be positive.)
   - State any common–sense reason you can see to doubt that the process will be polytropic with $n = 1.4$.

   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.*

Given: In black



$u_2 - u_1 = {}_1Q_2 - {}_1W_2$

(A) $PV = mRT$ (2) compute m, units (1) $m_2 = m_1$ (3) $P_2V_2^n = P_1V_1^n$ (2) compute P_2 (1) compute T_2

(4) Work formula (1) compute ${}_1W_2$, $W_{in} = -{}_1W_2$ (3) Read A-7.1 (4) Interpolate u_2 (5) 1st law (1) compute ${}_1Q_2$

heat (1) sign wrong way

Asked: $m_2, P_2, T_2, {}_1W_2, {}_1Q_2$? $n = 1.4$?

Solution: $P_1V_1 = m_1RT_1 \to m_1 = 90$ kPa 2 m³ / 0.287 kJ/kg K 300 K = 2.0906 kg = m_2

$P_2V_2^{1.4} = P_1V_1^{1.4} \to P_2 = P_1(V_1/V_2)^{1.4} \to P_2 = 2260.7$ kPa

$T_2 = P_2V_2/mR = 2260.7$ kPa 0.2 m³ / 2.0906 kg 0.287 kJ/kg K $= 753.57$ K $= T_2$

${}_1W_2 = \frac{P_2V_2 - P_1V_1}{1-n} = \frac{2260.7 \times 0.2 - 90 \times 2}{1 - 1.4}$ kPa m³ $= -680.35$ kJ $W_{in} = +680.35$ kJ

Table A-7.1 @ 300 K : $u_1 = 214.36$ kJ/kg
@ 753.57 K $= g$ $g_1 = 740$ K $d_1 = 544.33$ $g_2 = 760$ K $d_2 = 560.32$
$u_2 = d_1 + \frac{g - g_1}{g_2 - g_1}(d_2 - d_1) = 555.18$ kJ/kg

${}_1Q_2 = m(u_2 - u_1) + {}_1W_2 = 32.157$ kJ $= {}_1Q_2$

Since $T_2 = 753.57$ K ≈ 480°C, it does not make sense heat goes in.

9. (32%) A 2 kg/s high pressure stream of water at 2,000 kPa and 20°C enters an isobaric boiler at negligible speed. The water exits the boiler at 0.09 m^3/kg and 200 m/s.

   - Construct the initial phase in a very neat Tv-diagram, P first, marking all lines and points used to do it with their values. Do not put more info in the diagram than is needed to construct the phase. State the phase.
   - Construct the final phase in a second very neat Tv-diagram satisfying the same conditions as the first. This must be a separate diagram.
   - Find the heat added to the boiler per unit time to at least 5 significant 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. *Give the source of every number.*