Last Name:________________ First Name: _____________Thermo no. ______

ME 200 Thermodynamics 1
Fall 2017 – Exam 3

Circle your instructor's last name

Division 1: Naik **Division 2: Sojka**

Division 3: Wassgren **Division 4: Goldenstein**

Division 6: Braun **Division 7: Buckius**

Division 8: Meyer

INSTRUCTIONS

- **This is a <u>closed book</u> and <u>closed notes</u> exam. Equation sheets and all needed tables are provided.**
- Significant credit for each problem is given if you identify your system and its boundary, draw the relevant energy flows on a diagram i.e. Energy Flow Diagram (EFD), start your analysis with the basic equations, list all relevant assumptions, and have appropriate units and use three significant figures. There is no need to re-write the given and find.
- Do not hesitate to ask if you do not comprehend a problem statement. For your own benefit, please write clearly and legibly. **You must show your work to receive credit for your answers.**
- **<u>Do not write on the back of any page</u> because it will not be scanned so will not be graded**. If you need extra paper raise your hand and a proctor will supply it.

IMPORTANT NOTE

The use of PDAs, Blackberry-type devices, cell phones, laptop computers, smart watches or any other sources of communication (wireless or otherwise) is strictly prohibited during examinations. Doing so is cheating. If you bring a smart watch, cell phone, or other communication device to the examination, **<u>it must be turned off</u>** prior to the start of the exam, **<u>placed in your backpack, and the backpack must be stored below your seat</u>**. It shall be **<u>reactivated only after you leave the examination room for the final time</u>**. Otherwise it is a form of cheating and will be treated as such.

SECOND IMPORTANT NOTE

The only calculators allowed for use on this exam are those of the <u>TI-30X</u> series. No others.

Last Name:________________ First Name: _____________Thermo no. _____

1. [20 points] Circle the correct answer (no partial credit) for each.

(a) Entropy of air treated as an ideal gas depends only on temperature. (True or False)

(b) Enthalpy of air treated as an ideal gas depends only on temperature. (True or False)

(c) Enthalpy of water treated as an incompressible substance depends only on temperature. (True or False)

(d) Heat transfer is always zero during an isothermal process. (True or False)

(e) The entropy change of a substance undergoing an internally reversible process is always zero. (True or False)

(f) Entropy of a fluid undergoing an adiabatic, steady-state throttling process using a flow restriction (e.g. valve) device (Increases, Decreases, Remains the Same)

(g) Entropy of water treated as an incompressible substance undergoing an isothermal process (Increases, Decreases, Remains the Same)

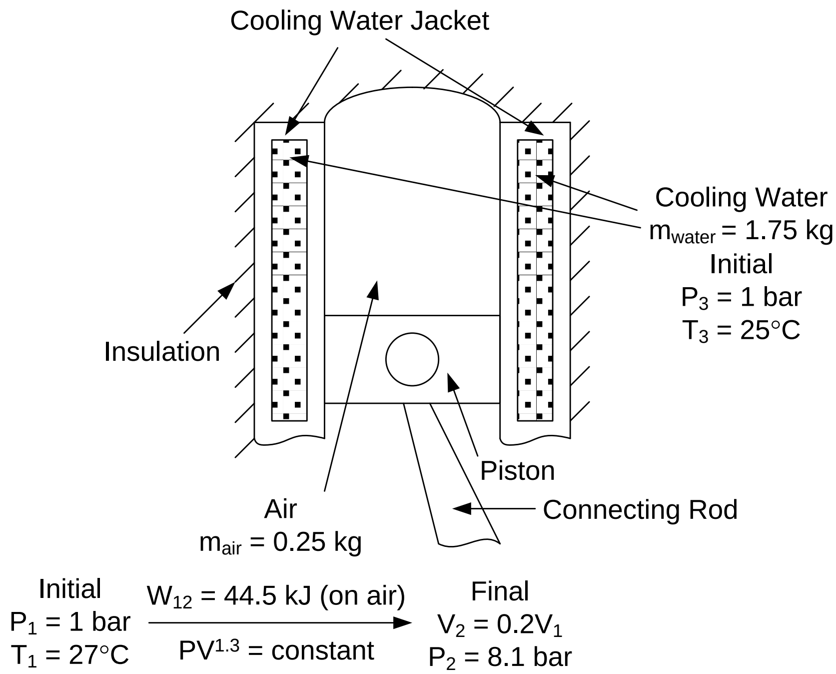
(h) Entropy of a pure substance undergoing a phase change from saturated vapor to saturated liquid at constant pressure (Increases, Decreases, Remains the Same)

(i) Change in entropy of a fluid having undergone a complete cycle in a reversible Carnot heat engine is (Positive, Negative, Zero)

(j) Change in entropy of a fluid having undergone a complete cycle in an irreversible heat engine is (Positive, Negative, Zero)

Last Name:________________ First Name: _____________Thermo no. _____

2. [40 points] A piston-cylinder device contains 0.25 kg of air initially at a temperature of 27°C and an absolute pressure of 1 bar (State 1). The air undergoes a compression process, where $PV^{1.3}$ = constant, until the volume is 20% of the initial volume and the absolute pressure is 8.1 bar (State 2). During the compression process, 44.5 kJ of work is done on the air. The cylinder is fitted with a cooling water jacket all around its outer wall. The cooling water jacket contains 1.75 kg of liquid water. The water is initially at a temperature of 25°C and an absolute pressure of 1 bar (State 3) at the start of the air compression process. Heat transfer occurs only between air in the cylinder and water inside the cooling jacket since the water jacket is perfectly insulated on its outside.



Molecular weight of air: 28.97 kg/kmol
Specific heat of liquid water: 4.18 kJ/kg-K
<u>Use the closest value in ideal gas table; do not interpolate.</u>

(a) What is the final temperature (°C) of water after the compression process?
(b) Calculate the entropy change (kJ/K) for the air.
(c) Find the entropy change (kJ/K) for the water.
(d) Determine the entropy generation for the entire process (both air and water).

<u>Identify appropriate system or systems on the sketch provided, show mass/energy interactions (EFD), list any assumptions and basic equations, and provide your solution. There is no need to re-write the given and find.</u>

Last Name:_______________ First Name: ____________Thermo no. _____

Extra Space for Problem 2

Last Name:________________ First Name: _____________Thermo no. _____

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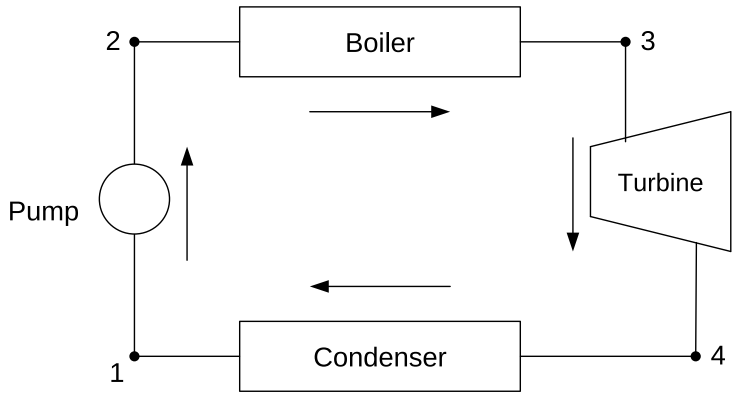
Last Name:________________ First Name: _____________Thermo no. _____

3. [40 points] A solar-powered steam power plant uses the sun's radiation to boil water. At peak operating conditions, the rate of radiation heat transfer into the boiler is 420 MW. The working fluid is water/steam, with data at each state provided in the table below; all the pressure values are absolute.



State	P, bar	T, °C	h, kJ/kg	ν, m^3/kg	s, kJ/kg-K
1	0.0123	10	42.0	0.00100	0.15109
2	40	10.1	46.3	0.000998	0.15210
3	40	600	3675	0.0988	7.3710
4	0.0123	10	2270	95.7	8.0249

P, bar	T_{sat}, °C	h_f, kJ/kg	h_g, kJ/kg	s_f, kJ/kg_K	s_g, kJ/kg_K
0.0123	10	42.0	2519.2	0.15109	8.8998
40	250.4	1087.5	2800.8	2.7968	6.0696

(a) Calculate the steam mass flow rate (kg/s) through the boiler.
(b) Compute the isentropic efficiency (%) of the adiabatic turbine.
(c) Find the entropy generation (kW/K) for the adiabatic turbine.
(d) Determine the total entropy generation (kW/K) for the condenser assuming heat transfer occurs to an environment of temperature 5°C.
(e) Show the cycle on T-s diagram relative to the vapor dome and the relevant lines of constant pressure. Label the axes and four states and indicate the process directions with arrows. For water: $T_{critical}$ = 374°C, $P_{critical}$ = 221 bar.

Identify appropriate system or systems on the sketch provided, show mass/energy interactions (EFD), list any assumptions and basic equations, and provide your solution. There is no need to re-write the given and find.

Last Name:_________________ First Name: ______________Thermo no. _____

Extra Space for Problem 3

Last Name:________________ First Name: _____________Thermo no. _____

Extra Space for Problem 3