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

DISCLAIMER

This practice exam is only for practice. The actual exam may not have a format similar to the problems included in this practice exam.

Selected answers are on the last page. Complete solutions will not be provided. You may check your solutions either with instructors or with teaching assistants during office hours.

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)

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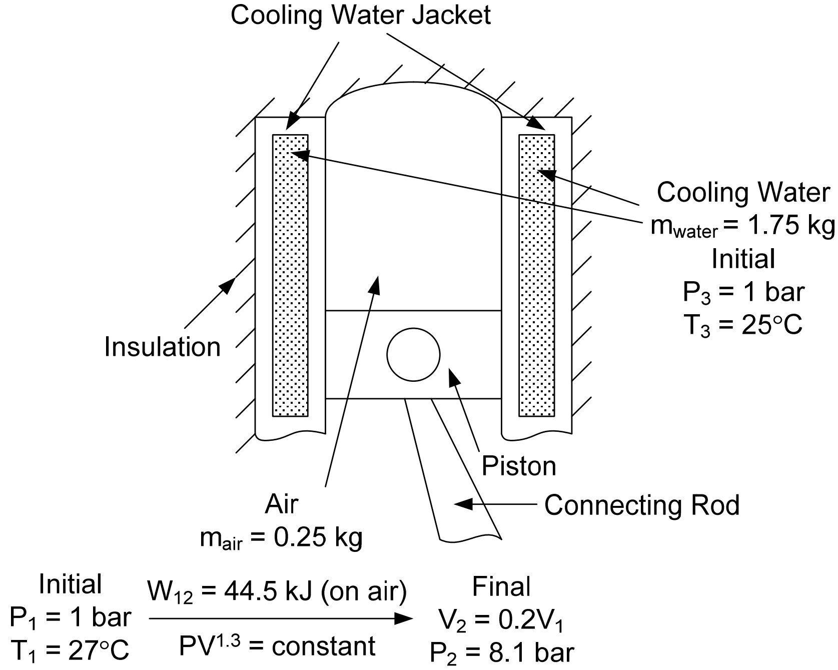
2. [40 points] A piston-cylinder device contains 0.25 kg of air initially at a temperature of 27°C and an absolute pressure of 1 bar (State 1). The air undergoes a compression process, where $PV^{1.3}$ = constant, until the volume is 20% of the initial volume and the absolute pressure is 8.1 bar (State 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
Use the closest value in ideal gas table; do not interpolate.

(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).

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.

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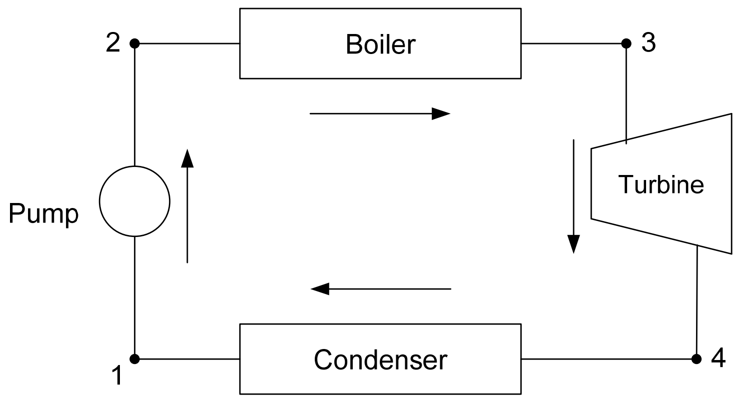
3. [40 points] A solar-powered steam power plant uses the sun's radiation to boil water. At peak operating conditions, the rate of radiation heat transfer into the boiler is 420 MW. The working fluid is water/steam, with data at each state provided in the table below; all the pressure values are absolute.



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.

Selected Answers

2(a) **26.4°C**

2(b) **-0.02584 kJ/K**

2(c) **+0.03428 kJ/K**

2(d) **+0.00844 kJ/K**

3(a) **115.7 kg/s**

3(b) **88.4%**

3(c) **+75.7 kW/K**

3(d) **+16.3 kW/K**