Last Name:_____ First Name: _____Thermo no. _____

ME 200 Thermodynamics 1
Fall 2017 – Exam 1

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.

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1. [20 points] Circle all (and only all) correct answers.

(a) Consider a lightbulb powered by electricity. Assume positive sign for heat transfer into the system and for work output from the system. Which of the following is true considering lightbulb as the system?

W > 0, Q > 0 W > 0, Q < 0

W < 0, Q > 0 W < 0, Q < 0

(b) Which of the following is (are) <u>true</u> for a fixed state containing only vapor?

$T < T_{sat}$ $P < P_{sat}$

$T > T_{sat}$ $P > P_{sat}$

(c) What is the quality for a saturated liquid-vapor mixture?

Ratio of volume occupied by vapor phase to total volume of the mixture
Ratio of volume occupied by liquid phase to total volume of the mixture
Ratio of mass occupied by vapor phase to total mass of the mixture
Ratio of mass occupied by liquid phase to total mass of the mixture

(d) A steel ball at 300°C is initially held stationary 100 m above the ground. The ball is then released, and the ball accelerates and cools during its fall to the ground. Assume air friction to be negligible. When is the total energy of the ball highest?

The instant it is released
Just before it hits the ground
Just after it hits the ground
The energy remains constant

(e) Which of the following is (are) <u>not true</u> for change in specific internal energy during a process with initial and final states having only liquid?

$\Delta u = u_2(P_2, T_2) - u_1(P_1, T_1)$ $\Delta u = u_f(P_2) - u_f(P_1)$

$\Delta u = C(T_2 - T_1)$ $\Delta u = u_f(T_2) - u_f(T_1)$

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2. [40 points] A piston-cylinder device contains a gas (which remains a gas throughout) undergoing a cycle with the following three processes:

Process 1-2: Constant pressure expansion at 10 bar absolute pressure
Process 2-3: Constant volume cooling
Process 3-1: Linear pressure increase from 5 bar absolute pressure (State 3) back to 10 bar absolute pressure at State 1

The data at various states in the cycle is provided in table below.

State	P, bar	V, m^3	U, kJ
1	10	0.5	200
2	10	1	400
3	5	1	200

(a) Sketch the three processes on a P-V diagram. Label the axes and all three states and indicate the process directions with arrows.
(b) Calculate the boundary work (kJ) for the gas during each process.
(c) Determine the heat transfer (kJ) for the gas during each process.
(d) Is this a power cycle or a refrigeration cycle? Justify your answer with appropriate calculation.
(e) Calculate thermal efficiency or coefficient of performance for the cycle.

<u>Identify the system, 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>

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Extra Space for Problem 2

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Extra Space for Problem 2

3. [40 points] A closed, rigid tank with a volume of 0.25 m^3 initially contains refrigerant R-134a at an absolute pressure of 6 bar and temperature of 60°C (State 1). The refrigerant is stirred with a paddle wheel device and the tank is cooled at the same time. The paddle wheel performs 10 kJ of work on the refrigerant. The refrigerant temperature drops to 12°C (State 2) due to the given energy interactions.

(a) Determine the mass (kg) of R-134a in the tank.
(b) What is the final pressure (bar) of R-134a in the tank?
(c) Find the heat transfer (kJ) for R-134a during the process.
(d) Show the process on P-v diagram relative to the vapor dome and the lines of constant temperature for the two states. Label the axes and two states and indicate the process direction with arrow.

<u>Identify the system, 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>

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Extra Space for Problem 3

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Extra Space for Problem 3