ME 200 Thermodynamics – Spring 2023
PREPARING FOR EXAM 1

I. Class Notes, Examples, and Quizzes

Review all class notes, examples, and quizzes**.** Do you understand all the concepts presented and discussed? Could you solve the examples and quizzes without looking at the solutions?

II. Homework Problems

Be able to solve all the homework problems without having to look at the solutions!

III. Previous Exam

One previous exam has been posted on your Brightspace site or your course site. Try to solve this practice exam in the time allotted for this 90-minute exam. Note Exam 1 is of 60-minute duration.

IV. Some Additional Practice Problems

1. Answer the following short questions:

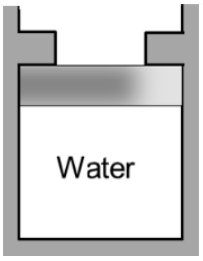
   A. Which assumptions are required in order to apply the equation $W_{12} = P(V_2 - V_1)$ to a system? Circle all that apply.
   a) ideal gas, b) incompressible, c) constant pressure process, d) quasi-equilibrium process

   B. A quantity of water is being stored at 20 bar and 50°C.

   Which choice is the closest to the specific internal energy of the water, in kJ/kg?
   a) 906.44, b) 2600.3, c) 209.33, d) 2443.5

   Which choice is the closest to the specific enthalpy of the water, in kJ/kg?
   a) 209.33, b) 2592.1, c) 908.79, d) 211.2

   C. Water at a pressure of 500 kPa and temperature of 500°C is contained in the piston-cylinder arrangement shown. There is a heat transfer from the water and the piston begins to move when the pressure reaches 100 kPa. There is an additional heat transfer until the temperature is 20°C. Show the process that the water undergoes on a P-v diagram with respect to saturation lines and indicate which phases are present at the beginning of the process, when the piston begins to move, and at the end of the process. Show appropriate constant temperature lines.

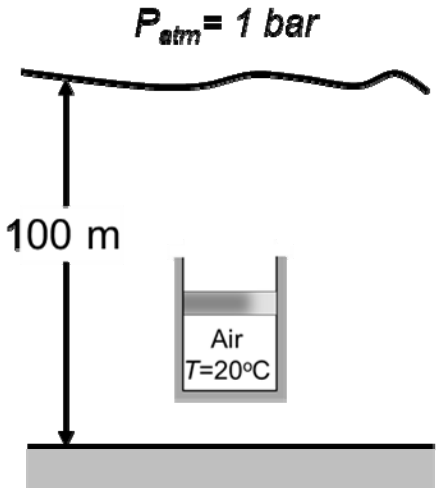


   D. Fill in the blanks in the following table for the properties of water.

	P, kPa	*T, °C*	*x,* %	*v,* m^3/kg	*u, kJ/kg*	Table used
a)	300	200				
b)	300		65			
c)		200		0.1050		
d)	4000			0.0584		
e)	2000	120				
f)	101.42	100				
g)		120		0.620		

E. Air treated as an ideal gas expands to a lower pressure in a closed piston-cylinder device. Heat transfer occurs from the surroundings so that the air temperature remains constant during the process. What happens to the internal energy of air as it expands? a) increases, b) decreases, c) remains the same, d) insufficient information. Justify using equation(s).

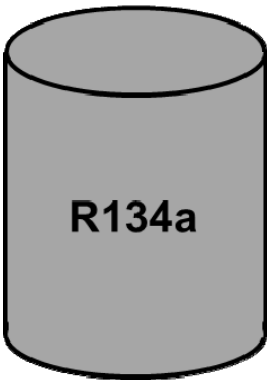
2. A small, un-insulated closed cylinder with a freely moving piston contains air and is accidentally dropped into a lake and falls slowly to the bottom at 100 m below the surface. Initially, the air in the cylinder is at atmospheric pressure of 100 kPa with a volume of 0.1 m^3 and a temperature of 20°C. The lake is also at a uniform and constant temperature of 20°C. As the cylinder falls, the air is compressed and there is a heat transfer for the air so that its temperature remains nearly constant at 20°C. Since air can be treated as an ideal gas this implies that the product of pressure and volume is constant (PV = constant) during the process.



Neglect the mass of the piston, friction, air leakage from the cylinder, potential energy and kinetic energy effects for the air and determine the following:

a) Final pressure of the air at the lake bottom, in kPa.
b) Final volume of the air at the lake bottom, in m^3.
c) Work done by the air in the device for the entire process, in kJ.
d) Heat transfer to the air in the device for the entire process, in kJ.

3. A used refill container for an automotive air conditioner contains 250 g of R134a. The container is made of steel and has a volume of 500 cm^3. Initially the container is in the house at a temperature of 20°C. However, the owner brings the bottle outside in the hot sun and the container and R134a temperature rises to 52°C. Do the following:

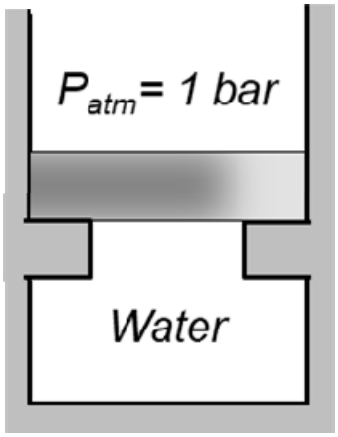


a) Determine the initial pressure of the R134a at the initial temperature, in kPa.
b) Determine the final pressure of the R134a at the final temperature, in kPa.
c) Show the process for the R134a on a P-v diagram with respect to saturation lines showing appropriate constant temperature lines.
d) Determine the work done by the R134a, in kJ.
e) Determine the heat transfer to the R134a, in kJ.

4. Given the three processes below for a gas. Note that the process 3→1 returns the closed system to the original state such that $\Delta U_{12} + \Delta U_{23} + \Delta U_{31} = 0$
   1→2: PV = constant, $\Delta U_{12} = 0$ (isothermal), $P_1 = 1$ bar, $V_1 = 1.6\ m^3$, $V_2 = 0.2\ m^3$
   2→3: $P_3 = P_2$, $V_3 = V_1$
   3→1: V = constant, $\Delta U_{31} = -3549$ kJ

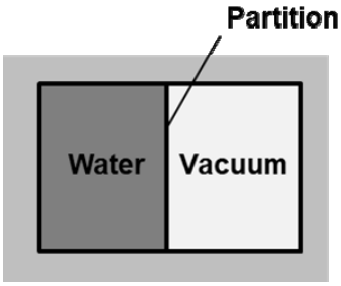
a) Draw the three processes on a P-V diagram.
b) Determine work and heat transfer for each process, in kJ.

5. Consider water in a piston-cylinder device with piston having negligible mass, sitting on stops, and exposed to ambient pressure as shown with the following conditions: $V_1 = 1\ m^3$, $m_{water} = 5$ kg, $T_1 = 50°C$, $P_{atm} = 100$ kPa.



a) Determine P_1, in kPa and u_1, in kJ/kg.
b) The mixture is then heated until the piston just begins to move. Determine P_2, in kPa, u_2, in kJ/kg, and Q_{12}, in kJ. Show the process on a P-v diagram.
c) The process continues until all the water is saturated vapor. Show the process on a P-v diagram. Determine P_3, in kPa, u_3, in kJ/kg, and Q_{23}, in kJ.
d) There is further heat transfer until the water temperature is 200°C. Show the process on a P-v diagram. Determine u_4, in kJ/kg and Q_{34}, in kJ.

6. An insulated tank is divided into two parts by a partition. One part of the tank contains 2.5 kg of compressed liquid water at 60°C and 600 kPa while the other part is evacuated. The partition is now removed, and the water expands to fill the entire tank. The final pressure is 10 kPa.



a) Determine the final temperature of the water, in °C.
b) Determine the volume of the tank, in m^3.

7. A balloon is filled with air and initially occupies a volume of 10 cm^3 at a pressure of 150 kPa and a temperature of 20°C. The balloon is then moved to a warmer environment of 40°C and comes into thermal equilibrium with a final volume of 10.5 cm^3. Assuming ideal gas behavior and a polytropic process (PV^n = constant) for the air, determine:

a) Work done by the air, in J.
b) Heat transfer to the air, in J.

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

Selected Answers

1.A. **c, d**

1.B. **c, d**

1.C. **SHV at State 1, SVLM at State 2, CL at State 3**

2. **a) P_2 = 1079 kPa, b) V_2 = 0.00927 m^3, c) W_{12} = -23.8 kJ, d) Q_{12} = -23.8 kJ**

3. **a) P_1 = 571.71 kPa, b) P_2 =1385.4 kPa , d) W_{12} = 0 kJ, e) Q_{12} = 12.9 kJ**

4. **W_{23} = 1120 kJ, Q_{23} = 4669 kJ**

5. **b) P_2 = 100 kPa, Q_{12} = 2082.5 kJ; c) Q_{23} = 9961 kJ; d) Q_{34} = 1002 kJ**

6. **a) T_2 = 45.81°C, b) V_2 = 0.972 m^3**

7. **a) W_{12} = 0.076 J, b) Q_{12} = 0.332 J**