

AREN 2110: Thermodynamics
Midterm 1
Fall 2004

_____ Name

Test is open book and notes. Answer all questions and sign honor code statement: I have neither given nor received unauthorized assistance during this exam.

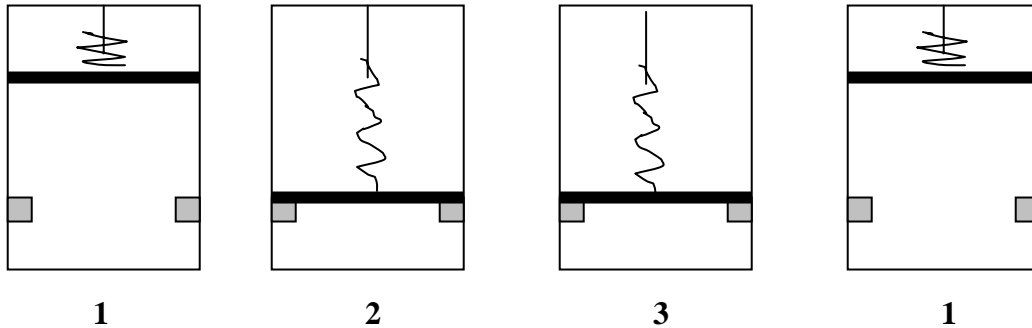
Signed _____

Remember to show your work – partial credit will be given for a correct approach!

<u>Question</u>	<u>Points</u>
1	/35
2	/30
3	/35
Total	/100

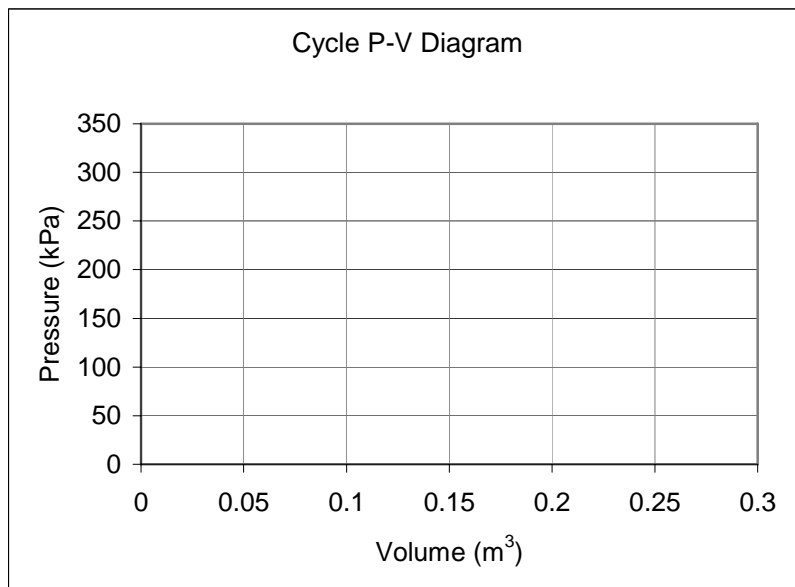
**AREN 2110 FALL 2007: IGNORE
PROBLEM 1 (YOU WON'T HAVE WORK
CALCULATION ON MIDTERM 1)**

1. (35 points) A device consisting of a piston-cylinder with an attached spring containing 0.25 kg air is operated in the cycle described below



- 1 → 2: At state 1 $P_1 = 200 \text{ kPa}$ and $V_1 = 0.25 \text{ m}^3$. The compressed linear spring is released and the air is compressed until the spring no longer stores energy and the piston is just resting on the stops: $P_2 = 300 \text{ kPa}$, $V_2 = 0.10 \text{ m}^3$
- 2 → 3: After compression, heat is removed and the pressure drops to 100 kPa at state 3.
- 3 → 1: Then heat is added, the linear spring is compressed, and the air expands until it reaches state 1.

b) Draw the process on the P-V diagram below. (5)



a) Find the temperature of the air at states 1 and 3 (T_1 and T_3). (5)

c) Calculate the total work done during process $1 \rightarrow 2$. (5)

d) Calculate the total work done during process $3 \rightarrow 1$. (5)

e) Calculate the net work for the cycle, and note if work is being done by the system or on the system. (5)

f) Calculate the work done by the spring in process $1 \rightarrow 2$. How does it compare with the work done on the spring in process $3 \rightarrow 1$? (5)

g) If the spring constant = 375 kN/m and the area of the piston is 0.75 m^2 , what is the displacement of the spring for process $1 \rightarrow 2$? (5)

2. (30 points total) An autoclave is a rigid-tank device where wet steam ($x = 0.7$) is used to sterilize equipment or other material. The working temperature of an autoclave with a volume of 0.1 m^3 (exclusive of material being sterilized) is $140 \text{ }^\circ\text{C}$.

a) What is the pressure in the autoclave vessel during operation? (5)

b) What is the mass of water that must be added to the autoclave at the start of the sterilization to maintain the working conditions above? (5)

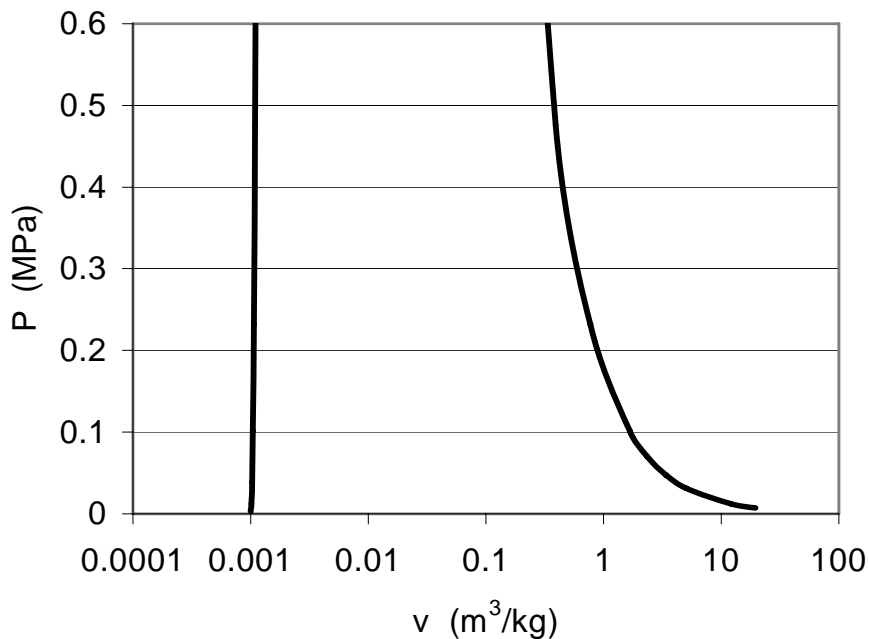
c) What is the volume of the added water at 100 kPa and $25 \text{ }^\circ\text{C}$? (5)

Autoclaves fail disastrously if the heater fails to shut off and the pressure rises beyond the capacity of the tank vessel. To prevent an explosion, a pressure relief valve is set to release steam when the pressure reaches 500 kPa.

d) Will there still be liquid water in the autoclave when the steam pressure reaches 500 kPa? Justify your answer. (5)

e) What would the temperature of the steam in the autoclave be just before the valve releases at 500 kPa? (5)

f) Draw the process going from normal operating conditions for the autoclave to maximum pressure on the P-v diagram for water below. (5)



3. (35 points total) A closed-system piston-cylinder device contains refrigerant (R-134a) at a pressure of 0.1 MPa, temperature of 241K and initial volume of 0.1 m^3 . The refrigerant is expanded in an isobaric process until the temperature reaches 303K.

a) What is the mass of refrigerant in the system? (5)

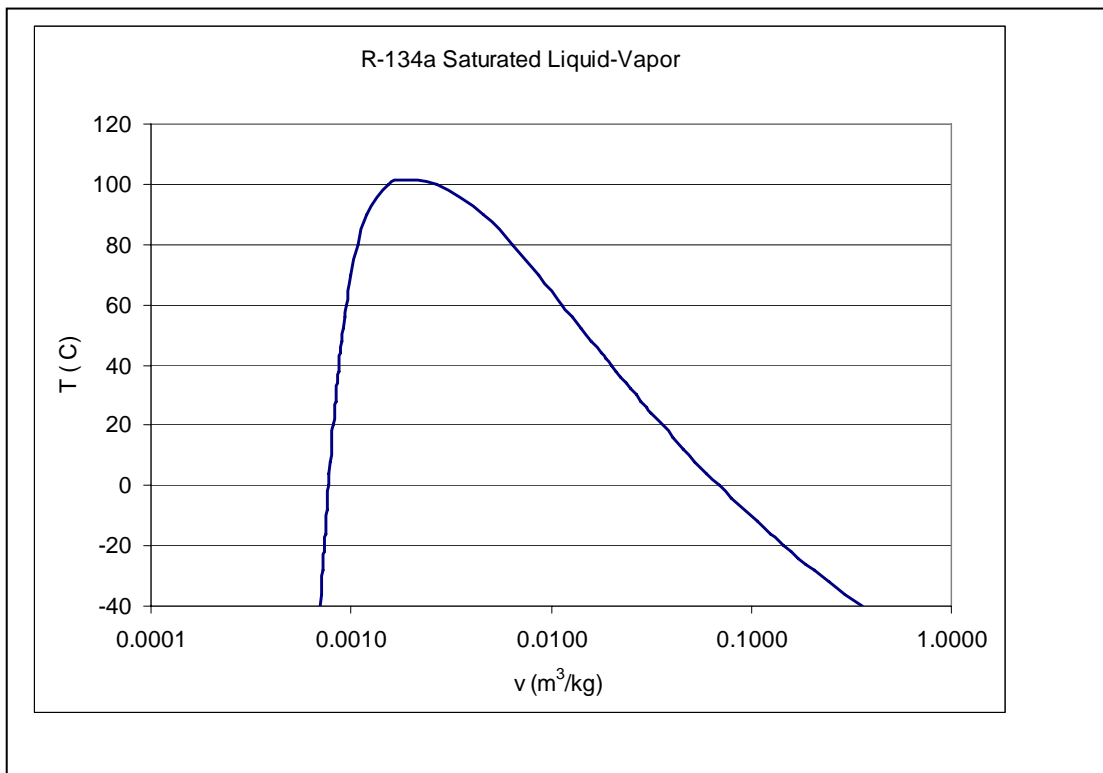
b) What is the total volume of the system after expansion? (5)

c) What is the change in energy of the system during the expansion (in kJ)? (5)

When the refrigerant temperature reaches 303K, energy is removed in an isothermal process until it is a saturated liquid.

d) What is the pressure of the refrigerant at the end of the isothermal process? (5)

e) Draw the two-step process on the T-v diagram for refrigerant below using values for temperature and specific volume: (5)



f) What is the net change in energy of the refrigerant over the two-step process? (5)

g) Draw the two-step process on the P - v diagram for refrigerant below using values for pressure and specific volume. (5)

