

AREN 2110: Thermodynamics
Midterm 1
Fall 2005

_____ 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	/35
3	/30
Total	/100

AREN 2110 FALL 2007: IGNORE QUESTIONS 2c, e, f, and g and 3 c

1. (35 points) A 0.2 m^3 container has 5 kg R-134a at 0°C (273 K) in a closed system at state 1.

a) What is the pressure of the R-134a at state 1? (5)

b) What is the mass of liquid refrigerant in the container at state 1? (5)

Heat is added and the R-134a expands in an isothermal process until $P = 100 \text{ kPa}$ at state 2.

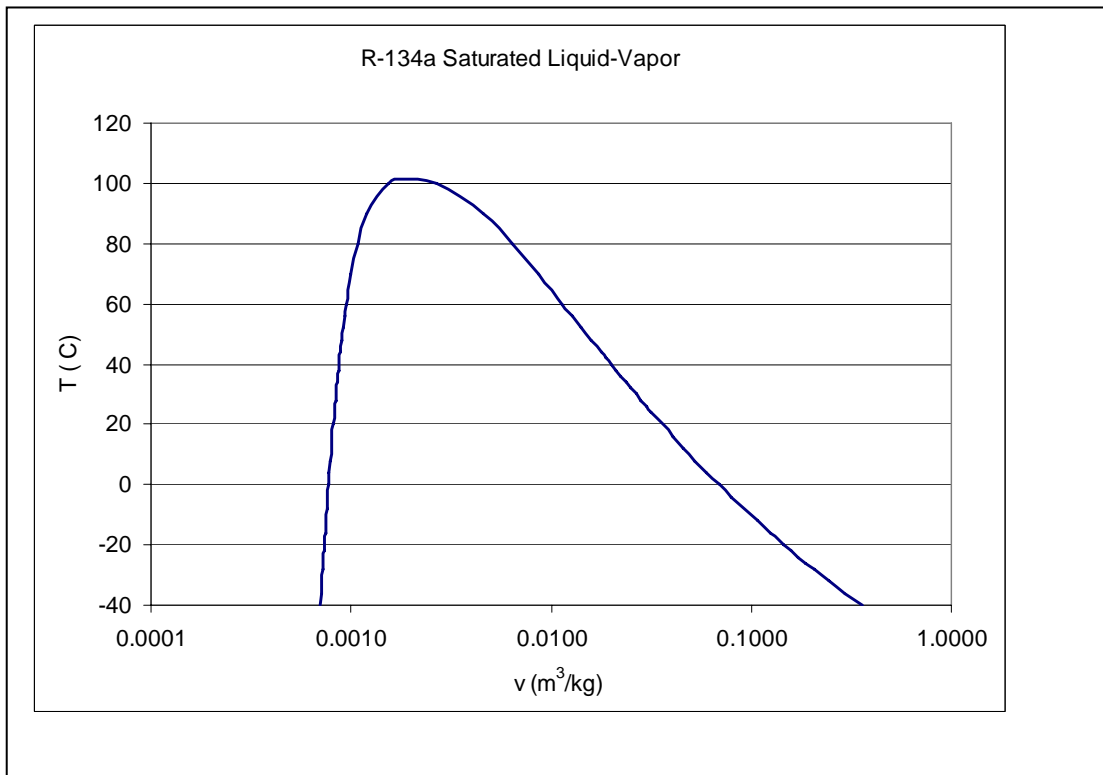
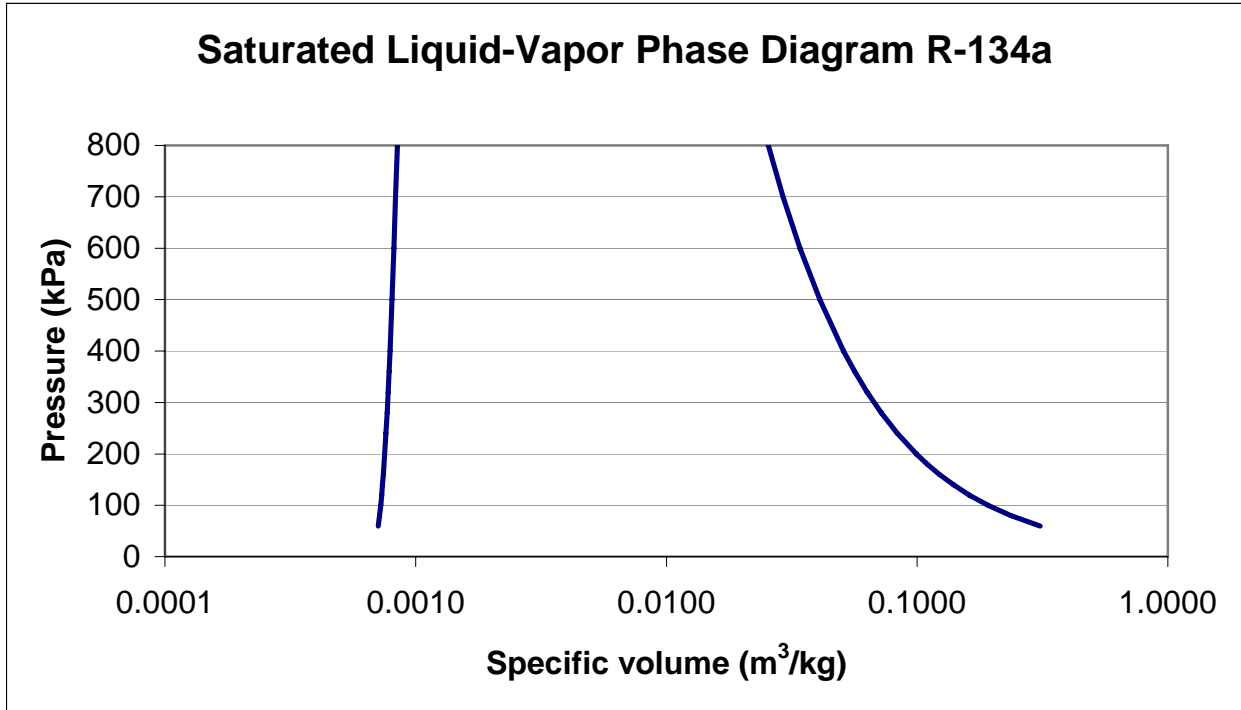
c) Calculate the change in enthalpy (ΔH) in kJ for process $1 \rightarrow 2$. (5)

Then heat is removed from the R-134a in an isobaric process until $T = -32^\circ\text{C}$ (241 K) at state 3.

d) What phase is the refrigerant at state 3? Justify your answer. (5)

e) Calculate the change in enthalpy (ΔH) in kJ for process $2 \rightarrow 3$. (5)

f) Draw the processes on the P-v and on the T-v diagrams next page (10)



2. (35 points) 7 kg of air, $T = 27\text{ }^{\circ}\text{C}$ and $P = 100\text{ kPa}$ is compressed in an isothermal process ($1 \rightarrow 2$) such that:

$$V_2 = \frac{V_1}{3}$$

- a) Calculate V_2 and P_2 at state 2 (5)
- b) What is the change in enthalpy (ΔH) for $1 \rightarrow 2$? (5)
- c) What is the boundary work of the system for $1 \rightarrow 2$? (5)

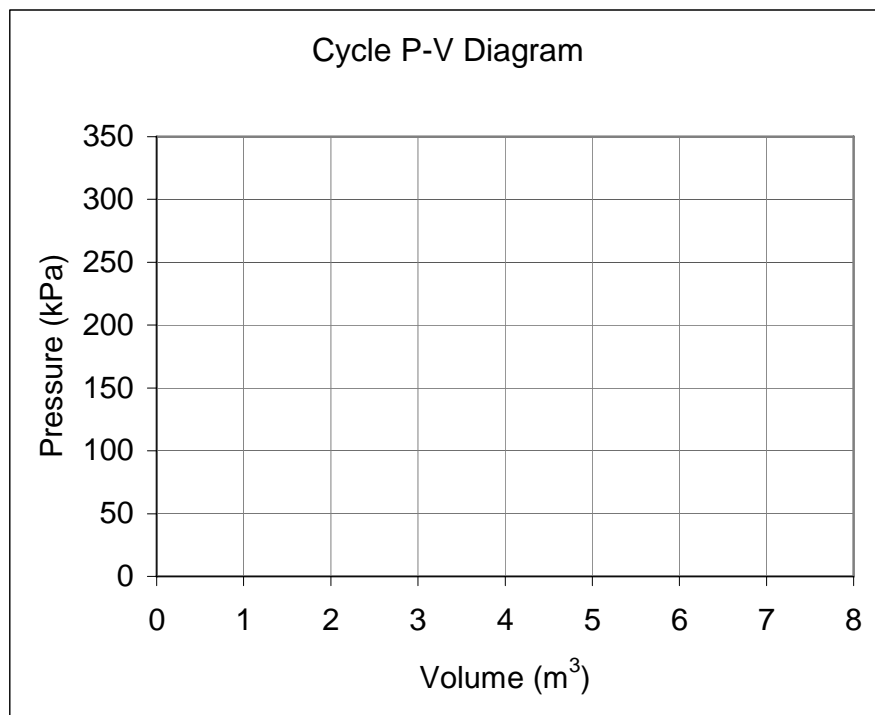
Heat is then added to the air, which expands in an isobaric process ($2 \rightarrow 3$) until $V_3 = V_1$.

- d) What is the change in enthalpy (ΔH) for the process $2 \rightarrow 3$? (5)
- e) What is the boundary work of the system for $2 \rightarrow 3$? (5)

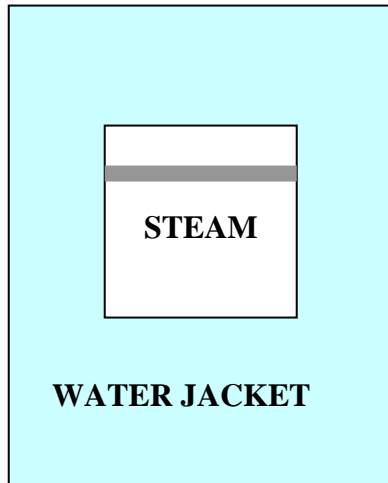
Finally, heat is removed from the air in a constant volume (isochoric) process until $P = P_1$.

f) Calculate the net boundary work of the cycle. (5)

g) Draw the cycle on the P-V diagram below. (5)



3. (30 points) Heat is removed from 10 kg wet steam $P = 50$ kPa and quality = 0.9, in an isothermal process until it is a saturated liquid. Heat is removed from the steam by transferring to a water jacket containing liquid water that surrounds the steam container (see diagram below).



- a) What is the volume of the steam before it is cooled?
(5)

- b) What is the change in enthalpy (ΔH in kJ) of the steam for the process?
(5)

- c) What is the boundary work of the steam for the process in kJ? (5)

- d) At the end of the cooling process, the water in the water jacket and the condensed steam are in thermal equilibrium. What is the temperature of the two substances? (5)
- e) Assuming the enthalpy change of the steam is equal to the enthalpy change of the water in the water jacket (but with the opposite sign), what mass of water with an initial temperature = 15 °C will be required in the water jacket for condensing the steam? (Specific heat for liquid water in this temperature range is 4.18 kJ./kg-K.) (5)
- f) Draw the process for the steam condensing on the P-v diagram for water/steam below. (5)

