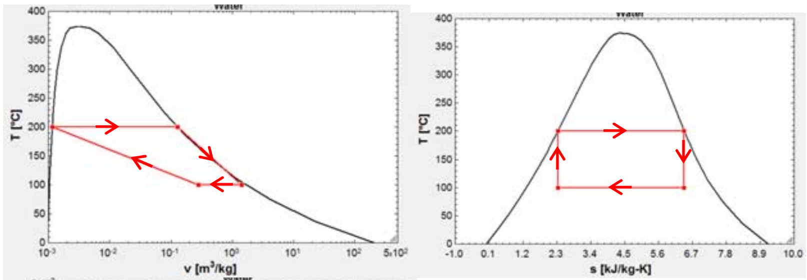
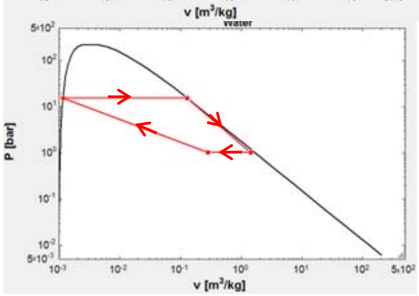
50

Name: ______________________ You are allowed three sheets of notes.

1. Fill in the blanks for each of the two (Carnot) cycles below.

(a)



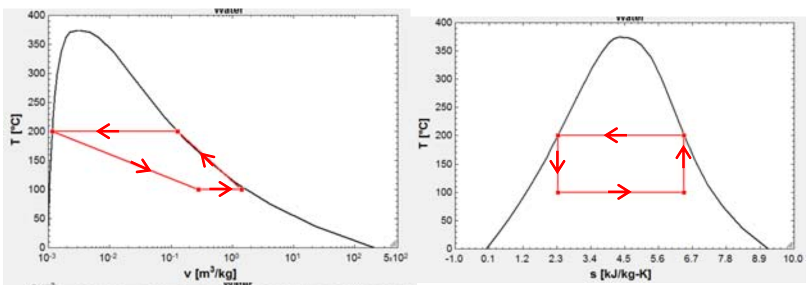


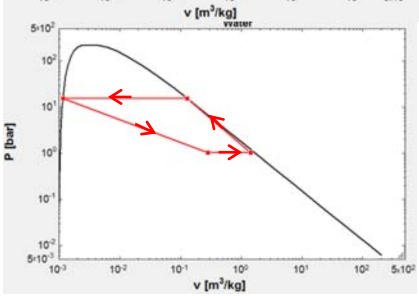
5

a) Heat engine or Heat pump/refrigerator (circle one)

b) Efficiency or Coefficient of performance: _____

(b)



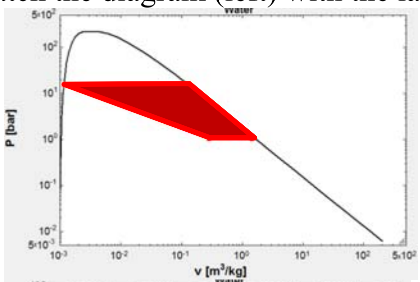


a) Heat engine or Heat pump/refrigerator (circle one)

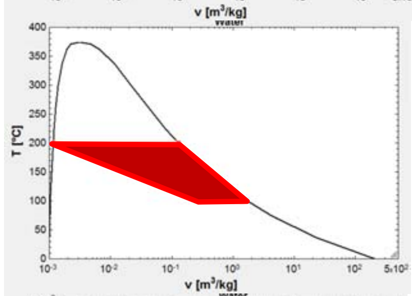
b) Efficiency or Coefficient of performance: _____

2. Match the diagram (left) with the label (right) for the shaded area.

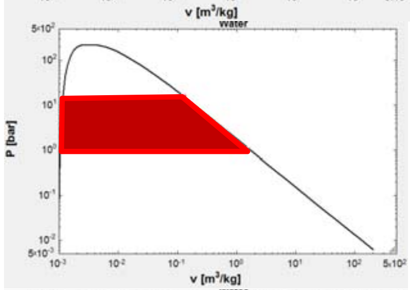
(a)



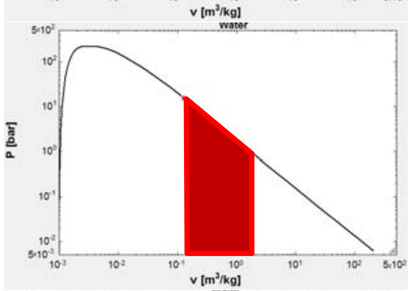
(b)



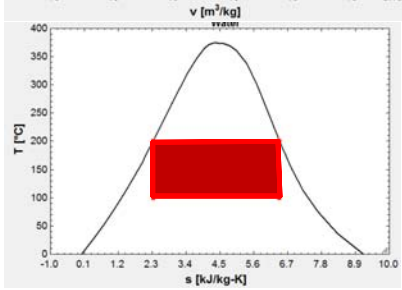
5 (c)



(d)



(e)



1. Net heat transfer per unit mass
2. Net work per unit mass
3. For closed systems
4. For open systems
5. Nothing we've studied

3. Fifty kJ of heat flows into a closed system at 50 °C and 100 kJ/K of entropy is produced irreversibly in the system. How much entropy is accumulated in the system?

5

4. Heat flows into a closed system at a rate of 50 kW at 500 °C and flows out at a rate of 30 kW at 20 °C. If the system is in steady state:
    a) At what rate is entropy produced irreversibly in the system?
    b) What rate of external work is done by the system?

5

5. One kg of water in a closed, expandable container is heated at atmospheric pressure (1.014 bar) from 20 °C to 100 °C. Find:
   a) The change in specific volume.
   b) The change in specific internal energy.
   c) The change in specific enthalpy.
   d) The change in specific entropy.
   e) The amount of heat added.
   f) The work done to expand the container.

15

6. One kg of water in a closed, expandable container is heated at atmospheric pressure (1.014 bar) from 20 °C to 100 °C. Using interpolated values from Table A-19 (c_p = 4.186 kJ/kg·K @ 60 °C, ρ = 997.4 kg/m^3 @ 20 °C, and ρ = 958.0 kg/m^3 @ 100 °C), find:

a) The change in specific volume.
b) The change in specific internal energy.
c) The change in specific enthalpy.
d) The change in specific entropy.
e) The amount of heat added.
f) The work done to expand the container.

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7. One kg of saturated liquid water in a closed, expandable container at 100 °C is heated at atmospheric pressure (1.014 bar) with 2000 kJ. Find:
   a) The change in specific volume.
   b) The change in specific internal energy.
   c) The change in specific enthalpy.
   d) The change in specific entropy.
   e) The work done to expand the container.

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8. One kg of saturated water vapor in a closed, expandable container at 1.0 bar pressure is heated to 200 °C. Find:
    a) The change in specific volume.
    b) The change in specific internal energy.
    c) The change in specific enthalpy.
    d) The change in specific entropy.
    e) The amount of heat added.
    f) The work done to expand the container.

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9. One kg of air in a closed, expandable container is heated from 295 K to 505 K at 101400 Pa pressure. Using the universal gas constant ($\bar{R}$ = 8.3144598 kJ/kmol·K), the molar mass of air from Table A-1 (M = 28.97 kg/kmol) and values at 400 K from Table A-20 (c_p = 1.013 kJ/kg·K, c_v = 0.726 kJ/kg·K, k = 1.395), find:

   a) The change in specific volume.
   b) The change in specific internal energy.
   c) The change in specific enthalpy.
   d) The change in specific entropy.
   e) The amount of heat added.
   f) The work done to expand the container.

15

10. One kg of air in a closed, expandable container is heated from 295 K to 505 K at 1.014 bar pressure. Using the gas constant for air (R = 0.287058 kJ/kg·K) and the properties from Table A-22:

- 295 K: h = 295.17 kJ/kg, u = 210.49 kJ/kg, s^o = 1.68515 kJ/kg·K
- 505 K: h = 508.17 kJ/kg, u = 363.21 kJ/kg, s^o = 2.22973 kJ/kg·K

find:

a) The change in specific volume.
b) The change in specific internal energy.
c) The change in specific enthalpy.
d) The change in specific entropy.
e) The amount of heat added.
f) The work done to expand the container.

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11. Liquid water flows at atmospheric pressures into a container from one source at a rate of 3 kg/s at 20 °C and from another source at 2 kg/s at 10 °C. Water flows out of the container at a rate of 5 kg/s at 30 °C. If no work is being done and the system is in steady state:
    a) At what rate does heat enter the system according to the energy rate balance?
    b) If the heat enters at 40°C, at what rate does the heat enter the system according to the entropy rate balance, in the internally reversible case?
    c) Is there a logical way to reconcile these values?

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12. A pump pumps 1 kg/s of liquid water at 20 °C from atmospheric pressure (1.014 bar) to a pressure of 25 bar.

   a) What temperature is the pressurized water leaving the pump, in the isentropic case?
   b) If there are internal irreversibilities, will the temperature be higher or lower?
   c) How much work does the pump need to do in the isentropic case?